

STATE
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OF

TENNESSEE
January 1, 2015
City of Franklin
Williamson County

SPECIAL PROVISION

REGARDING

SECTION 730 – TRAFFIC SIGNALS

DESCRIPTION

730.01 Description of Work

This work consists of furnishing and installing all necessary materials and equipment to complete in-place traffic signal systems, modify existing systems, or both, all as shown on the Plans or the Standard or Special Details, City of Franklin Standard Drawings and as specified in these Specifications. Unless otherwise shown on the Plans or specified in the Special Provisions, all materials shall be new.

Where existing systems are to be modified, incorporate the existing material into the revised system, salvage it for return to the City of Franklin, or abandon it as specified or as directed by the Engineer.

Furnish and install all incidental parts that are not shown on the Plans or specified herein, but that are necessary to complete the traffic signal or other electrical systems, or that are required for modifying existing systems, as though such parts were shown on the Plans or specified herein. Include the costs of such incidentals in bid price for other items. All systems shall be complete and in operation to the Engineer's satisfaction at the time of completion of the work. This is to include but not limited to the traffic signal system work, traffic signal communications, traffic signs, traffic markings and any other work required to ensure that the traffic signal system can function as per the final plans.

Notify the Department and the City in writing when the work is complete in order that the final inspection can be scheduled and performed by the Department and City of Franklin.

Operate and maintain the traffic signal system until such time that system testing is complete and a final inspection is performed. All discrepancies found in the inspection shall be corrected to the satisfaction of the Department and the City of Franklin. The City of Franklin will assume maintenance responsibilities once all discrepancies are corrected and a written final acceptance document is produced by the City.

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 and the NESC; the Standards of ASTM, ANSI, ITE, and IMSA; the MUTCD; and the City of Franklin adopted codes and permitting process.

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, submit to the Engineer, the Traffic Operations Division, and the City of Franklin, one collated set of the manufacturer's descriptive literature and technical data that fully describes the types of signal equipment proposed for use. In the descriptive literature, identify the manufacturer and models and include sufficient information for the Engineer to determine if the equipment or material meets the requirements of the Plans and these Specifications. Include with these sets of submittal data a list of the materials submitted along with descriptive material for, but not limited to, the following items:

1. Controller
2. Cabinet and Exhaust Fan
3. Detectors/Detection Devices
4. Signal Heads including Lamp Information and Mounting Hardware
5. Loop Wire and Loop Sealant
6. Shielded Detector Cable
7. Signal Cable
8. Cable for Span Wire, Guys, and similar features
9. Pull Boxes
10. Conduit
11. Coordination Equipment
12. Support Pedestals, Poles and Mast Arms
13. Communication Cable
14. Communications Equipment
15. Electrical Service Connection

Also include in the submittal sets detailed scale drawings of all non-standard or special equipment and of all proposed deviations from the Plans. Upon request, submit for approval sample articles of materials proposed for use. The Department and the City of Franklin will not be liable for any materials purchased; labor performed, or delay to the Work prior to such approval.

In addition to the above, submit to the Engineer a notarized letter certifying that all traffic signal materials listed in the submittal conform to the Plans and Specifications along with a copy of a statement from the City of Franklin that the system is acceptable. Any material substitutions requested by the City of Franklin shall meet minimum Department and City standards and shall be approved by the Department and City in writing prior to purchase or installation. Once approval has been given, provide proof of order of said materials within seven days of approval. The Department and City will not be liable for any materials purchased; labor performed, or delay to the Work regarding such approval.

Submit an electronic copy in PDF format of "Design" or "Shop" drawings, indicating the proposed dimensions and material specification for each of the supports and mast arms involved, to the Division of Structures for approval purposes within 30 days after the work order is issued. The Department and City will review these drawings at the earliest possible date, and will return the electronic copy marked "Approved for Fabrication," or "Returned for Revisions as Noted." Respond by taking appropriate action to ensure the earliest possible correction of these items so as not to delay the installation.

730.04 Mill Test Reports and Certification

Provide Mill Test Reports (MTR) or Certifications of Conformance to the Specifications for Materials and Design for all materials incorporated into the Work. Supply the following prior to acceptance of the structures:

1. MTRs for MAJOR structural items only, as identified in Table 730.04-1, shall include both physical and chemical descriptions of the material as supplied to the fabricator. When physical properties are altered during the fabrication, supplement the MTR covering chemical composition with certified test reports indicating the physical properties of this material after fabrication.

2. Certifications of Conformance to the Specifications for all remaining material not covered by MTR as identified in Table 730.04-1.
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.

Table 730.04-1: Required Mill Test Reports and Certifications

Component Materials	MTR	Certification
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

Provide within the controller cabinet and to the City of Franklin an electrical schematic diagram of the cabinet and system wiring. Submit manufacturer’s instructions for installation, maintenance, and operation of all equipment to the City of Franklin and also place a copy within the controller cabinet. Place all such materials inside a plastic envelope mounted in the cabinet.

730.06 Guarantee

Guarantee the Traffic Signal System(s) installed under these Specifications, including all equipment, parts, and appurtenances in connection therewith, to the City and State against defective workmanship and materials for a period of not less than 1 year following the date the signal system is installed and made operational, except in no case shall this guarantee expire prior to 3 months after the final acceptance of the Project. Upon completion of the Project, turn over to the City of Franklin all warranties or guarantees on equipment and materials that are offered by the manufacturers as normal trade practice.

730.07 Training

Provide to the City of Franklin and/or the Department a training session on the controller and associated cabinet equipment to be supplied on the Project. The training session shall last for a minimum 8 hours unless the City and/or the Department determines a lesser time is adequate. Train the user in the complete operation and programming features of all controllers. Provide this training prior to the acceptance of the Project at a facility agreed upon by the City of Franklin.

After the required training, certify to the Engineer that training has been completed.

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

MATERIALS AND INSTALLATION**730.08 Excavating and Backfilling**

Perform excavation needed to install conduit, foundations, and other equipment, so as to cause the least possible damage to the streets, sidewalks, and other improvements. Excavate trenches no wider than necessary to properly install the electrical equipment and foundations. Do not begin excavating until immediately before installing conduit and other equipment. Place the material from the excavation where it will cause the least disruption and obstruction to vehicular and pedestrian traffic and the least interference with the surface drainage.

Backfill the excavations and compact to at least the density of the surrounding material. Remove all surplus excavation material and dispose of outside the highway right-of-way, in accordance with **203.07**, or as directed by the Engineer.

After backfilling, keep excavations well-filled, and maintain 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, remove all equipment and other obstructions from that portion of the roadway used by public traffic, and park a minimum of 30 feet from the edge of pavement unless otherwise protected by guardrail, bridge rail, or barriers installed for other purposes.

Perform excavation in the street or highway so as to restrict no more than one traffic lane in either direction at any time. Do not obstruct traffic during hours of peak flow unless otherwise approved by the Engineer. Incorporate construction signing in accordance with the MUTCD.

730.09 Removing and Replacing Improvements

Replace or reconstruct, with the same kind of materials as found on the Work, improvements, such as sidewalks, curbs, gutters, Portland cement concrete and asphalt concrete pavement, bituminous surfacing, base material, and all other improvements removed, broken, or damaged.

Before removing the sidewalk and pavement material, use an abrasive type saw to cut, to a minimum depth of 2 inches, the outline of all areas to be removed in Portland cement concrete sidewalks and in all pavements. Use any method satisfactory to the Engineer to cut the remainder of the required depth. Make cuts 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, remove the entire square or slab and reconstruct the concrete as specified above.

Perform all work in accordance with these Specifications, or the applicable local ordinance, whichever is of a higher standard. Consider this removal and replacement work to be incidental to other items.

730.10 Foundations

Construct foundations for posts, standards, and cabinets of Class A Portland cement concrete in accordance with Department or City of Franklin Standard Drawings, as applicable.

Pour foundations for posts, standards, and pedestals after the post, standard, pedestal, or anchor bolts or reinforcing steel is in proper position. Form the exposed portions to present a neat appearance. Rest the bottom of concrete foundations on firm undisturbed ground.

Construct forms to be true to line and grade. Finish tops of footings for posts and standards, except special foundations, to curb or sidewalk grade or as ordered by the Engineer. Use rigid forms, securely braced in place. Place conduit ends and anchor bolts by means of a template until the concrete sets. Moisten both the forms and the ground that will

be in contact with the concrete before placing concrete. Do not remove forms until the concrete has cured for at least 12 hours and hardened sufficiently to allow form removal without causing damage to the concrete.

Apply an ordinary surface finish to exposed surfaces of concrete. Wherever the edge of a concrete foundation or sidewalk section is within 18 inches of any existing concrete improvement, extend the sidewalk section to meet the existing improvement.

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

730.11 Anchor Rods

Furnish, with anchor-base type rods, anchor bolts meeting the requirements of ASTM F1554, grade as required by design. Fit each anchor bolt with two heavy hex nuts. Hot-dip galvanize all nuts and not less than 10 inches of the threaded ends of anchor bolts according to ASTM A153. The anchor bolts shall be capable of resisting at yield strength stress the bending moment of the shaft at its yield strength stress.

Set standards, posts, and pedestals plumb by adjusting the nuts before the foundation is finished to final grade. Do not use shims or similar devices for plumbing or raking. After plumbing or raking has been completed, cut off anchor bolts 1/4 inch above the top nut, and paint the exposed surface with rust protective paint.

Furnish all anchor bolts and nuts required for relocating existing standards and posts.

730.12 Pull Boxes

Construct and install pull boxes as shown on the Plans and the TDOT and City of Franklin Standard Drawings or as directed by the Engineer. Additional pull boxes may be required where traffic signal and/or electrical conduit runs are more than 150 feet long. The maximum spacing between traffic signal and electrical pull boxes shall be 150 feet, unless otherwise directed by the Engineer. Maximum spacing for fiber optic pull boxes shall be 500 feet. Install pull boxes wherever practicable out of the line of traffic. Set covers level with the pavement, or with the curb or sidewalk grade, or with the surrounding ground as required. Pull box covers shall be stamped with either the words "TRAFFIC SIGNALS" or "COF FIBER OPTIC" inscribed to the same specifications as directed by TDOT and City of Franklin standard drawings and specifications.

Place electrical conductors within pull boxes so as to be clear of the metal frame and cover.

Rest the bottom of the pull box firmly on a bed of crushed stone with a minimum depth of 12 inches below the bottom, and extending 6 inches beyond the outside edge of the pull box, unless otherwise directed by the Engineer.

A. Concrete Pull Boxes

Construct concrete pull boxes of a mixture of one part cement, two parts sand, and four parts gravel or 1-inch crushed stone with reinforcement placed as shown on the Standard Drawings. Reinforcement shall consist of welded wire reinforcement, 4 x 4 inches - No. 4/4 at 85 pounds per 100 square feet, meeting the requirements of **907.03**. Pull boxes may be poured in place or precast. The color of the pull box concrete material shall match the surrounding concrete color.

Install a cast iron frame and cover of the dimensions shown on the Drawings in each pull box. Provide castings of Class 30, meeting the requirements of **908.07**. The covers shall have a roughened top surface of 1/8 inch in relief. Provide notches for removing the cover. Inscribe the words "TRAFFIC SIGNALS" on top of the covers with letters 1-1/2 inches high and 1/8 inch in relief as shown on the Drawings.

The frame shall have a minimum weight of 42 pounds. The cover shall be of the "Extra Heavy" type with a minimum weight of 54 pounds.

B. Reinforced Plastic or Epoxy Mortar Pull Boxes

Ensure that pull boxes composed of reinforced plastic or epoxy mortar are designed and tested to temperatures of -50 °F and meet the requirements of the following: ASTM D543, ASTM D570, ASTM D790, and ASTM D635, and are based on a 30,000-pound single axle load over a 10 x 20 inch area. The top of the pull box shall consist of a concrete frame (ring) and cover. The color of the pull box concrete material shall match the surrounding concrete color. Inscribe the words "TRAFFIC SIGNALS" or "COF FIBER OPTIC", as applicable on top of the covers.

C. Precast Composite Concrete Pull Boxes (Fiber Optic Type A and B)

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.

Pull Boxes and covers shall be single-stack open-bottom assemblies configured as shown in the Plans.

Vertical Design / Test Load shall be - 22,500lbs/33,750lbs. Loadings shall comply with ANSI 77 2007 and shall exceed Tier 15 test provisions for both the cover and sidewall.

Pull Box shall meet NEC for handhold enclosures.

Inscribe the words "COF Fiber Optic" on top of the covers with letters 1-1/2 inches high and 1/8 inch in relief as shown on the Plans.

730.13 Transformer Base

Fabricate the transformer base from steel plate and sheet, and design it to harmonize with the shaft. Provide each transformer base with:

1. One 7-1/2 x 9 inch minimum handhole, with a cover secured with stainless steel fastening screws;
2. Four galvanized steel bearing plates to fasten the base to the anchor bolts;
3. Four galvanized steel bolts, nuts, and washers to fasten base and standard; and
4. One 1/2-inch, 13 UNC grounding nut welded to the inside of the base opposite the handhole opening.

Ensure that the strength of the transformer base is comparable with that of the shaft.

When a transformer base is required, no handhole will be required in the shaft.

730.14 Conduit

Furnish and install plastic and steel conduit 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 allow proper coupling. Do not use long running threads on any part of the Work. Protect threads in transit and during installation, and provide conduit with proper supports and protection during construction to prevent damage. Properly thread, ream, and cap all ends of pipe installed for future connections to prevent water and foreign matter from entering the conduit system. Provide threaded ends with approved conduit bushings.

Signal conduit shall be a minimum 2 inches in diameter, and detector conduit a minimum 1 inch in diameter, unless otherwise specified or directed by the Engineer. Conduit for service connections shall be 1 inch in diameter. Do not use conduits smaller than 1 inch in diameter unless otherwise specified, except grounding conductors at service points shall be enclosed in 3/4-inch diameter conduit. Larger-sized conduit may be used, at no additional cost to the Department, in which case it shall be for the entire length of the run with no reducing couplings allowed.

A. Materials

Provide conduits and fittings of the type as shown in the construction plans or as directed by the Engineer and 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 C80.1. It shall be galvanized inside and out and shall meet the requirements of ASTM A53. 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 C80.1 and UL Standard 6 with a minimum 40-mil thickness of polyvinyl chloride (PVC) coating conforming to ASTM D746.

2. Plastic Conduit. For plastic conduit, provide high impact PVC, Schedule 40 or Schedule 80.**3. High-Density Polyethylene (HDPE).** Materials used for the manufacture of HDPE conduit and fittings shall be per ASTM F2160 and consist of a Standard Dimension Ratio (SDR) 9-11. No other substitutions shall be allowed unless directed by the Engineer. HDPE conduit can be used with preassembled cable and rope-in-conduit.

Conduit shall be extruded from colored material for uniform full-thickness coloring. 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 "COF Communications" and sequential foot marking. Labeling shall occur a maximum of every 2 ft.

4. 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.
- c. All couplings shall be installed in accordance with the conduit and the coupling manufacturer's recommendations.
- d. Only couplings of the type specified below and approved by the conduit manufacturer are permitted.
- e. Couplings shall be accomplished only by hydraulic press-on or electro-fusion coupling methods.
- f. Use hydraulic press-on couplings of seamless tool-grade tubular aluminum with sealing ring barbs and center stop.
- g. Use hydraulic compression duct coupling tools and follow all manufacturer's installation procedures, fully inserting both conduit sections to the coupling center stop.
- h. Use pre-fabricated electro-fusion couplings that are field-installed using the coupling manufacturer's recommended automatic self-monitoring fusing machine and installation procedures.
- i. Do not use any other coupling methods.

B. Installation

All bends shall be in strict compliance with the NEC.

Lay conduits to a minimum depth of 6 inches below subgrade but not less than 24 inches below pavement grade except when approved by the Engineer; conduit may be laid at a depth of not less than 24 inches below top of curb when placed in back of the curb. Place conduit runs for detectors parallel to existing or proposed curbs and not more than 18 inches behind the curb face unless other specified. Place steel conduit or Schedule 80 PVC conduit under existing pavements by approved jacking or drilling methods. Do not disturb pavements without the Engineer's approval. Where trenching is allowed in a traffic bearing area, use PVC conduit (Schedule 40) encased in concrete.

Conduits shall be continuous and extend from end point (i.e. pull box, foundation signal pole, pedestal pole, etc.) to another end point, or as directed by the Engineer. Conduit splicing shall not be permitted between end points.

After completing the installation of the conduit, test all conduits installed under the Contract with a mandrel having a diameter 1/4-inch smaller than the conduit and a length of 2 inches. Repair, to the Engineer's satisfaction, all conduits that will not allow passage of the mandrel; if repairs cannot be accomplished, remove and replace the conduit at no additional cost to the Department. After the mandrel test, scour all conduits with a stiff wire brush slightly larger in diameter than the conduit. Clear all conduits in the Engineer's presence.

Extend conduits terminating in anchor base standards and pedestals approximately 2 inches above the foundation and slope them toward the hand-hole opening. Conduits shall enter concrete pull boxes from the bottom and shall terminate not less than 2 inches or more than 4 inches above the bottom of the box and near the box walls to leave the major portion of the box clear.

Clean existing underground conduit to be incorporated into a new system by blowing with compressed air and wire brush mandrel, or by other means approved by the Engineer.

Seal all open conduit entrance holes, with or without cables, with conduit duct seal putty. Where cables enter the conduit, the sealant shall be applied after installing the cable. These locations shall consist of conduit ends in pull boxes, cabinet bases and weather heads.

All fiber optic conduit installed shall include a polyolefin pull string for future conductor pulls and shall have a tracer wire (#10 AWG bare copper stranded) for all fiber optic conduit installations.

AWG#14 trace/locate wire shall be installed in all empty conduit runs and spliced between boxes to form a continuous run. Any fiber optic conduit shall be terminated in "Type B" fiber optic pull box unless otherwise specified. Fiber optic conduit shall have Type 2 Warning Tape installed a minimum of twelve (12) inches below finished grade.

730.15 Conductors

Furnish and install conductors in accordance with these Specifications and close conformity as shown on the Plans, or as directed by the Engineer.

Traffic Control Conductors shall be rated at 600 volts. Run all conductors, except loop conductors and cables run along messengers, in conduit, except where run inside poles. Where signal conductors are run in lighting standards containing high voltage street lighting conductors, encase the signal conductors in flexible or rigid metal conduit. Where telephone circuits are introduced into controller foundations, encase the telephone conductors in flexible metal conduit and in conformance with the NEC.

Conductors for traffic loops shall be continuous AWG No. 14 XLP stranded wire to the detector terminals or spliced with shielded detector cable within a pull box, conduit, or pole base.

Detector cable shall be two conductor twisted pair shielded AWG No. 14 stranded meeting IMSA Specification No. 50-2.

730.16 Cable

All signal cable shall conform to applicable IMSA Specification No. 19-1 or 20-1. Use stranded cable color coded AWG No. 14 for all signal and accessory circuits. Retain the same color identification for the entire length of a circuit run.

730.17 Wiring

1. Terminate all wiring to screw terminals using lugs.
2. Make all splices with solderless connectors, and insulate splices with weatherproof tape applied to a thickness equal to the original insulation.
3. Splices shall be permitted only in pull boxes, pole base, or controller cabinets.4. Attach cables to messenger with non-corrosive lashing rods or stainless steel wire lashings.
5. All wiring within enclosed cabinets shall be neatly formed and harnessed and shall have sufficient length for access and servicing.

730.18 Service Connection

Coordinate service connection details and metering with the local utility as directed by the Engineer and in conformance with the City and County requirements. Obtain an electrical permit from the City of Franklin Codes Department prior to constructing the service installation.

Provide AC service installation to supply the following:

1. 100-amp main breaker with one (1) 50-amp breaker for the traffic signal installation, three (3) 30 amp breakers, one each for the illuminated signs, safety lighting and a spare which may be used for project specific ITS infrastructure.
2. Each 30-amp breaker shall be labeled for its use. Locate photocell for illuminated street name signs and safety lighting at the service disconnect with a test/bypass switch.

Underground service connection shall be installed per the City of Franklin Standard Drawings. The electrical service pedestal shall be a Milbank Model No. CP3B51110A22SL1, Tesco Model No. 26-000 M, or approved equivalent.

730.19 Sealant

Provide sealant material selected from the Qualified Products List maintained by the Department's Material and Test Division for sealing saw-cuts. The sealant material 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 the anticipated temperature and weather conditions. Inductive loop detectors shall be installed without flexible tube or backer rod.

730.20 Strand Cable

Span cable for suspending signal heads between pole supports shall be 7-strand, Class A, copper-covered steel wire strand or greater, meeting the requirements of ASTM A460, with a minimum breaking strength as noted on the Plans. An acceptable alternate is 7-strand steel wire with a Class A zinc coating meeting the requirements of ASTM A475, with a minimum breaking strength as shown on the Plans.

Strand cable for messenger wire (other than span wire as specified above) and pole guy cable use shall be of the diameter(s) shown on the Plans and shall meet the requirements of ASTM A475 for zinc-coated steel wire strand, 7-strand Siemens-Martin Grade with a Class A zinc coating or greater.

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.

730.21 Bonding and Grounding

Make metallic cable sheaths, conduit, transformer bases, anchor bolts, and metal poles and pedestals mechanically and electrically secure to form a continuous system, and ensure they are 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.

Furnish and install a ground electrode at each service point. Ground electrodes shall be one-piece lengths of copperweld ground rod not less than 8 feet in length and 1/2 inch in diameter, installed in accordance with the NEC. Ground the conduit and neutral as required under the NEC, except that grounding conductors shall be No. 6 AWG or approved equal, as a minimum. Enclose exposed ground conductors in 1/2-inch diameter conduit, and bond to the electrode with a copperweld ground clamp.

730.22 Field Test

Prior to completing the work, conduct the following tests on all traffic signal and lighting circuits in the Engineer's presence:

1. Test for ground in circuit.
2. Conduct 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 NEC.
3. Conduct a functional test to demonstrate that each part of the system functions as specified or intended herein. The functional test shall be submitted and approved by the Engineer.
4. Test all detector loops and leads before and after they are sealed in the pavement to ensure there are no shorts to ground in the system and to ensure that the loop plus lead-in inductance is within the operating range of the detector.

Replace or repair, in a manner approved by the Engineer, all faults in material or in the installation revealed by these tests. Repeat the applicable testing until no fault appears.

Prior to turn on for full signal actuated functionality, a new traffic signal shall be placed into flash operation for a minimum of 7 days prior to the activation of the signal to normal operation, unless otherwise directed by the Engineer.

730.23 Inspection

After completion of the installation and before final acceptance of the Project, conduct a full operational check of the system under actual traffic conditions in the presence of the Engineer. The operational check shall cover a minimum time period of 30 calendar days. During this period, perform all necessary adjustments and replace all malfunctioning parts of the equipment required to place the system in an acceptable operational condition at no additional cost to the Department. Perform all work and furnish all materials required under these Specifications subject to the direct supervision, inspection, and approval of the Engineer. Provide the Engineer and authorized representatives free access to the work, and to all plants, yards, shops, mills, and factories where, or in which, articles or materials to be used or furnished in connection with such work are being prepared, fabricated, or manufactured. Provide full and sufficient information to determine that the performance of the work, the character of materials, and the quality of workmanship and materials meets the intent of these Specifications.

Only perform work in the presence of the Engineer or the Inspector appointed by the Engineer, unless permission to do otherwise has first been obtained. The Engineer may reject any work that is performed or constructed in the absence of the Engineer or Inspector, without such permission having been granted, either expressly or by implication.

The inspection of the work shall not relieve the obligation to properly fulfill the Contract as specified. If the Engineer finds a part of the work, or the materials used in the work, to be defective or unsuitable at any time prior to final acceptance, repair or replace such defective or unsuitable work or material.

Request the presence of an Engineer or Inspector in connection with the work under these Specifications at least 24 hours before such services will be required.

SIGNAL HEADS

730.24 Signal Heads

Signal heads shall meet the latest requirements published in the Equipment and Materials Standards of the Institute of Transportation Engineers (ITE) for Adjustable Face Vehicle Traffic Control Signal Heads” and the National Electrical Code. The arrangement of traffic signal heads shall be mounted as shown on the Plans or as specified by the Engineer and be in accordance with the latest versions of the MUTCD and the TDOT Traffic Design Manual.

Each vehicle signal head shall:

1. Be of the adjustable, colored lens, vertical type with the number and type of lights detailed as specified herein and as shown on the Plans;
2. Provide a light indicator in one direction only;
3. Be capable of adjustment (without attachments) through 360 degrees about a vertical axis;
4. Signals mounted on mast arms shall be done with an “Astro-Brac Clamp Kit, Galvanized Cable Mount” type hardware, Skyclamp Cable Clamp Kit SBC64-CCK, or approved equivalent

All circular indications shall use 12-inch Light Emitting Diodes (LED), lenses unless otherwise shown on the Plans. All arrow indications shall use 12-inch LED lenses, unless otherwise shown on the plans. All lenses shall be polycarbonate. All new vehicle signal heads installed at any one intersection shall be of the same style and from the same manufacturer. All exposed metal signal housings, doors, visors, backplates and framework parts shall be painted with a powder coated finish and be in accordance to the MUTCD specifications. Apply one or more coats of primer to all signal heads, signal head and mountings, followed by two coats of high quality synthetic resin enamel of Traffic Signal Black meeting or exceeding Federal Specifications TT-C-595 Gloss Black. Apply one or more coats of primer to all signal hoods followed by two coats of high quality synthetic resin enamel of Traffic Signal Black meeting or exceeding Federal Specifications TT-C-595 Gloss Black. Apply one or more coats of primer to louvers as specified, signal hood interiors, and back plates, followed by two coats of Lusterless Black Enamel meeting or exceeding Master Painters Institute (MPI) Reference 94. Examine all factory enameled equipment and materials for damaged paint after installation, and repair such damaged surfaces to the Engineer's satisfaction. 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 5-section signal head) shall include an approved swivel type balance adjuster for proper vertical alignment.

Signal head housings shall be cast aluminum and all associated parts/hardware shall be of non-corrosive material. The signal hood shall be of the cutaway tunnel type, secured to the front section of the door with four stainless steel machine screws that thread into tapped holes in the door. Ensure that all signal heads meet the minimum Contract requirements for adjustable face vehicle traffic control signal heads. In addition to these requirements, comply with the following:

A. Optical Units

Traffic signal indications shall be LED type and meet the Institute for Transportation Engineers (ITE) latest LED specifications. All LED indications shall have a five year warranty.

A. Signal Head Mounting and Mounting Brackets

Furnish signal heads that either have integral serrations or are 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. Provide signals with water-tight fittings.

Support bracket-mounted signal heads, as shown on the Plans, by mounting brackets consisting of assemblies of 1-1/2 inch standard pipe size. Ensure that all members are both plumb or level, symmetrically arranged, and securely assembled. Conceal all conductors within poles and mounting assembly. Secure each slip fitter to the pole.

B. Directional Louvers

Where shown on the Plans, furnish and install louvers in the hoods of the signal head sections designated.

Directional louvers shall have a snug fit in the signal hoods. Construct the outside cylinder and vanes from a non-ferrous metal or galvanized sheet steel. Louvers shall be painted with a powder coated finish and as specified above.

C. Back Plates

Where shown on the Plans, furnish and attach back plates to the signal heads. All back plates shall be louvered and constructed of Polycarbonate. Other materials such as plastic or fiberglass may be used where approved. In fabricating back plates, bend back the inside vertical edges, adjacent to the signal head, to form mounting brackets for attaching to the signal. Form back plates in two or more sections and bolt together, thus allowing for installation after signal heads are in place. Back plates shall have a dull black appearance in the front and back with applied 2" retro reflective yellow border (ASTM Type XI) 3M Diamond Grade 4000 series prismatic sheeting, Avery Dennison T-11500 OmniCube series sheeting, or approved equal, unless noted otherwise in plans.

D. Wiring

Signal head leads shall be No. 18 AWG stranded with 221 °F thermoplastic insulation. Wire a separate white (common) lead to each socket shell; and wire a colored lead, corresponding to the color code shown on the Plans, to each socket terminal. Provide leads of sufficient length to allow connection to the terminal block specified. Provide each complete signal head with a minimum 4-point terminal block, properly mounted in a signal section. Stud type terminal blocks shall have not less than 1/4-inch edge clearance to any portion of the stud. Exterior wiring shall have a 360-degree drip loop in advance of entering the head.

Signal heads and pedestrian signal heads shall be installed with a minimum single 7 conductor cable and as indicated on the plans.

All new and existing cables shall be labeled in the cabinet, pole/pedestal bases and pull boxes using the convention of TDOT Standard Drawings. Each wire shall be identified by a circular plastic tag, 1 3/8" diameter with preprinted lettering of minimum 1/4" height. Tags shall be permanently fastened to wire by means of nylon self-clinching straps. Marking shall indicate "GRD" for all ground and grounded neutral conductors. Companion circuit conductors shall be marked "CKT" followed by the designated characters as shown on the plans.

E. Pedestrian Signals

Pedestrian signal heads shall meet the latest requirements published in the Equipment and Materials Standards of the Institute of Transportation Engineers (ITE) for Adjustable Face Pedestrian Signal Heads”, the National Electrical Code and be compatible with NEMA standards. The arrangement of pedestrian signal heads shall be mounted as shown on the Plans or as specified by the Engineer and be in accordance with the latest versions of the MUTCD and the TDOT Traffic Design Manual. The pedestrian indications including countdowns shall be LED symbols and in conformance with the Institute for Transportation Engineers (ITE) latest countdown and LED specifications. All LED indications shall have a five year warranty.

In addition, where pedestrian signal heads are provided, they shall:

1. Include a pedestrian change interval countdown display where the calculated pedestrian change interval is more than 7 seconds;
2. Include Accessible Pedestrian Signals and pedestrian pushbuttons complying with MUTCD Accessible Pedestrian Signals section;
3. Incorporate a locator tone meeting the requirements of the MUTCD Accessible Pedestrian Signals;
4. include a pedestrian pushbutton with tactile vibrating arrow button and audible sound.

The pedestrian countdown display shall conform to the latest FCC regulation on Emission of Electronic Noise.

The manufacturer must supply certification, which includes a copy of the test report by an independent technical laboratory as to the 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 polycarbonate or approved equal. Hinge pins shall be stainless steel. Provide the door with a neoprene gasket capable of making a weather resistant, dust-proof seal when closed.

All pedestrian signal heads, mountings, outside of hoods, and pedestrian push button housings shall have a powder coated finish (if aluminum) or colored resin (if polycarbonate) in accordance to MUTCD specifications. All pedestrian signals shall be painted with black enamel meeting or exceeding Federal Specifications TT-C-595 Gloss Black. The interior of signal hoods shall have one or more coats of primer followed by two coats of Lusterless Black Enamel meeting or exceeding MPI Reference 94. Examine all factory enameled equipment and materials for damaged paint after installation and repaint such damaged surfaces to the Engineer's satisfaction. Factory applied enamel finish in good condition and of appropriate color shall be acceptable, as approved by the Engineer.

F. Signal Head Installation

Install signal heads and pedestrian signal heads with the faces completely covered until the entire installation is ready for operation.

CONTROLLERS – GENERAL**730.25 Controllers**

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. A minimum of 30 days prior to turn on, contact the City of Franklin Traffic Operations Center to arrange the delivery of the new controller for programming by the City. Upon City installation of the timings in the controller, retrieve the controller and install it at the intersection.

Controller equipment shall be permanently marked with the manufacturer's name or trademark, part number, and serial number.

Controllers must meet the following applicable industry standards and amendments:

1. NEMA TS2 Controller NEMA TS-2-2016
2. ATC Controller AASHTO/ITE/NEMA ATC 5.2b
3. All NEMA TS2 and ATC controllers must provide functionality that meets or exceeds operational characteristics, including NTCIP support, as described in NEMA TS-2-2016.
4. ATC controllers with NEMA TS2 Type 2 connectors shall be utilized by the City.

With the latest upgrade of the TACTICS central system software, the City of Franklin requires the Siemens M60 type ATC Series Traffic Controller. The controller mechanism shall meet or exceed the current NEMA Traffic Signal Systems Standard. Provide Standard A, B, C and D Connectors and Synchronous Data Link Control (SDLC) connectors. Submit private laboratory certification that the proposed unit is in complete compliance with the NEMA standards in effect at the time of the advertisement for bids.

The controller shall have all timing values entered via a front panel mounted keyboard, as well as a cable connection with a laptop computer. The keyboard and connection port shall be integral parts of the controller unit.

Each controller shall have all operating timing parameters as specified in NEMA on a per phase basis, including all Volume/Density features. Each phase shall have a defined Last Car Passage feature wherein the last vehicle receiving the Phase Green shall receive at least one full Passage Time increment.

The controller shall have all of the following keyboard entered values or parameters:

1. Start on condition of the controller where the user can select via the keyboard the following:
 - a. Phases to start in
 - b. Phase display to be on
 - c. Overlap display start-on condition
 - d. Normal start-up display shall be main street green phase(s), with concurrent overlaps green
2. Phase recall functions:
 - a. Non-lock detector
 - b. Lock detector call
 - c. Minimum recall
 - d. Maximum recall
 - e. Pedestrian recall
 - f. Non-actuated phase
 - g. Phase not active, phase omitted
 - h. Pedestrian phase omitted
3. All phase interval timing values except the Phase Yellow Clearance shall be as per NEMA. Each controller Phase Yellow Clearance Interval is 3 seconds as a minimum.

The controller shall have a back-lit liquid crystal display for each ring of the controller 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:

1. Per Phase Display:
 - a. Phase Vehicle Call
 - b. Phase Pedestrian Call
 - c. Phase is Next In Service

- d. Phase is In Service
 - e. Phase Pedestrian Intervals in Service
2. Per Ring Display:
- a. Ring Gapped Out
 - b. Ring Maximum Green Termination
 - c. Ring was Force Off Terminated
 - d. Ring Maximum Green II in effect
 - e. Ring Phase in Service Operating:
 - i. Lock Call
 - ii. Non-Lock Call
 - iii. Minimum Recall
 - iv. Maximum Recall
 - v. Pedestrian Recall
 - vi. Non-Actuated Mode
3. Per Ring Display of Timing Values (Real Time). The following values shall be selectively displayed and shall display the current value in a real time mode.
- a. Minimum Green Interval
 - b. Passage Timer
 - c. Pedestrian Interval Timing
 - d. Maximum Green Timer
 - e. Time Before Reduction Timer
 - f. Time to Reduce Timer

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.

The controller shall store all operator entered data in EEPROM devices that require no battery to support value storage. No internal components of circuitry shall require battery support.

Except for replacing controllers in existing systems, all new installations must include controllers that capture high resolution event-based data elements to provide the automated traffic signal performance measures.

The manufacturer must supply certification of the conformance to the above requirements at the time of the bid.

In addition to the above requirements, the controller shall:

1. Have all timing values entered via a front panel mounted keyboard. This keyboard shall be an integral part of the controller unit.
2. Have an English language menu for programming or reading all controller features.
3. Continue to operate the intersection as values are inspected or altered.
4. Include the ability to upload and/or download the controller software operating system and user programmed database to or from external media (datakey, usb, sd card etc).
5. Support Flashing Yellow Arrow for Permissive Left-turn Movements applications
6. Assure overlap omit by ped call

Surge Protection Devices

The cabinet shall have Surge Protective Devices (SPDs) for the main AC power input, all signal head field wiring terminals, interconnect cable terminals and loop lead-in cable terminals which are located in the cabinet. Furnish SPDs to provide effective defense against high transient voltages caused by lightning discharges or other sources. SPDs must be unobstructed and accessible from the front side of any panel used in the cabinet. The SPD for the main AC power input of the cabinet must be connected on the load side of the cabinet circuit breaker. SPDs must meet the following minimum requirements:

1. AC power SPD:
 - a. Must be UL 1449 4th Edition Listed
 - b. Parallel connected device
 - c. UL Nominal Surge Rating (In): 20kA
 - d. UL Short Circuit Current Rating (SCCR): 150kA minimum
 - e. Surge current rating: 50kA per phase minimum
 - f. Visual status indication
 - g. Remote signalization contacts for monitoring purposes
 - h. 10 year manufacturer's warranty minimum
2. DC power SPD:
 - a. Must be UL 1449 4th Edition recognized
 - b. Parallel connected device
 - c. UL Nominal Surge Rating (In): 10kA minimum
 - d. Must provide protection between all +/-Gnd connections
 - e. Surge current rating: 20kA per phase minimum
 - f. Visual status indication
 - g. Remote signalization contacts for monitoring purposes
 - h. 10 year manufacturer's warranty minimum
3. Data and communication SPD:
 - a. Must be UL 497B listed
 - b. 10 year manufacturer's warranty minimum
4. Signal and interconnect cable field wiring terminal SPD:
 - a. Clamp the surge voltage to a level no greater than twice the peak operating voltage of the circuit being protected.
 - b. Withstand a surge current of 1000A with an 8 by 20 μ s waveform six times (at 1 second intervals between surges) without damage to the suppressor.
 - c. 10 year manufacturer's warranty minimum
5. Loop lead-in cable field wiring terminal SPD:
 - a. Protect the detector unit loop inputs against differential (between the loop lead) surges, and against common mode (between loop leads and ground) surges
 - b. Clamp the surge voltage to 25 V or less when subjected to repetitive 300A surges
 - c. Withstand repetitive 400A surges with an 8 by 20 μ s waveform without damage
 - d. 10 year manufacturer's warranty minimum

All SPDs must be installed according to the SPD manufacturer's instructions and not affect the operation of equipment. SPD leads must be kept as short and straight as possible.

CABINETS – GENERAL

730.26 Cabinets

Cabinets must be permanently marked with a label including the manufacturer's name or trademark, model/part number, and the year and month of manufacture. The label should be placed on the inside of the main door using a water resistant method. The label must be visible after installation.

Cabinets shall be provided as a complete unit and have all terminals and facilities necessary for traffic signal control as shown on the plans and shall meet at a minimum, the following requirement:

NEMA TS2 Type 1 Controller Cabinet NEMA TS 2 2016

The manufacturer must supply certification of the conformance to the above requirements at the time of the bid. Cabinets shall also be in accordance with the latest version of the TDOT Traffic Design Manual.

Two paper copies of the cabinet wiring diagram shall be provided with each cabinet. The nomenclature of signal heads, vehicular movements and pedestrian movements on the wiring diagram must be in accordance with the signal operating plan. Documentation must include a list identifying the termination points of cables used for vehicular and pedestrian signal heads, detector loop lead-ins, and pedestrian pushbutton wires. A heavy duty, resalable plastic bag must be mounted on the backside of main cabinet door for storing cabinet documentation.

House the controller in a rigid, weatherproof cabinet, constructed, finished, and equipped as follows, and as shown on the Plans and Standard Details:

1. Material, Workmanship, Dimensions and Layout

- a. Completely fabricated from .125": thick type 5052-H32, vinyl coated, mill finished aluminum utilizing intermittently welded construction, waterproofed with silicone sealant. Mill finish aluminum shall be required unless noted on plans to be powder coated or vinyl wrapped. Wraps shall be customizable to work with local artists and photographs. Wrap graphics and text shall be provided by the City. Cabinet wrap shall be installed at traffic cabinet manufacturer's facility by personnel certified by the wrap manufacturer or by field personnel certified by the wrap manufacturer. Wrap shall be made of a 2 mils (not millimeters) conformable graffiti-resistant vinyl. Material shall utilize a non-flammable, self-extinguishing grey opaque adhesive that blocks substrate color from showing through. Wrap shall be laminated with an optically clean UV protectant gloss laminate that resists and protects against light abrasion, scratching, spray paint, markets, adhesives and/or chemicals. Wrap shall have a material warranty of 1 year from the date of installation.
- b. All pad mounted cabinets shall be 56" in height. The width of the cabinet shall be 44" . The depth of the cabinet shall be a maximum of 27" unless a different size is specified in the plans. The inside of the cabinet shall be able to house the battery backup system by double stacking the load bays and allowing battery shelves next to the load bay terminals towards the bottom of the cabinet. Due to many size differences between manufactures we will accept cabinet height sizes from 55" to 57" so long as shelving and terminals as specified are adequately allowed.
- c. Internal attaching components shall include a total of 12 adjustable "C" channel mounting studs for shelving and panels., 4 per side, and 4 slotted rails on the rear wall.
- d. Two full width shelves shall be in the top controller compartment portion of the cabinet. A slide out laptop shelf with storage shall be mounted below the second from the top shelf. Two additional shelves shall be located in the lower portion of the cabinet alongside the double stack load bays to accommodate the battery backup/UPS components.

- e. Thermo-convection air ventilation system utilized with provisions for mounting fan for forced air cooling. A minimum of two fans with thermostats shall be included. Exhaust outlet openings are provided under the roof over-hang.
- f. All internal and external hardware shall utilize non-corrosive material.

2. Doors

- a. The door openings shall be double flanged on the top, bottom and sides to prevent water from entering the cabinet. The openings shall include a mount for two door-operated switches.
- b. Doors shall be provided with a three-point locking mechanism.
- c. 3/4" diameter stainless steel inward turning handle on the controller compartment door. Provide handle for padlocking.
- d. Doors shall be equipped with industrial Medeco Signal Cabinet Lock P/N TrafficCab 101 Lock and Medeco XT Slim Line, or as specified in the plans. A minimum of one Medeco key shall be supplied with each cabinet.
- e. Door shall accommodate louvered inlet with filter to prevent dirt from entering with air flow.
- f. A closed-cell neoprene door seal gasket shall be used.
- g. Doors are to be mounted with 4 stainless steel hinges utilizing a non-removable 1/4" diameter hinge pin for support, carriage bolted in place for ease of door removal.
- h. A 2" deep, fabricated switch compartment is included with a standard "police" lock and 18-gauge stainless steel continuous hinge with a 1/8" diameter hinge pin riveted in place shall be included on both doors. Compartments shall be mounted flush to the door.

3. Back Panel

- a. Shall be wired for 8 vehicle movements, 4 pedestrian phases and 4 overlaps (sixteen channels). Pedestrian phases shall be LS9-LS12 and Overlaps shall be LS13-LS16.
- b. Sixteen NEMA input and output indicating load switches and bases shall be provided.
- c. Shall be wired for 8 flash relay bases to allow any loadswitch (phase) outputs to flash Yellow, Red, or no-flash.
- d. Cabinet Main Back Panel signal outputs shall use both color-coded red, yellow and green wires and red, yellow and green labels for easy identification.
- e. All pedestrian and overlap signal wires shall feed to their back-panel positions from below the terminal strips and not travel over the face of the back-panel and other signal wires.
- f. Provide 4 terminal screw downs per channel, one each for red, yellow, green and flash.
- g. Color-coded labels shall be placed on the inside of the front cabinet door to illustrate the procedure for changing the signal output flash colors.
- h. All detection shall utilize the SDLC port.

4. Bus Interface Unit (BIU)

Cabinet shall include:

- a. One BIU that shall be a NEMA designated BIU2 as listed in Table 8-1 of NEMA Standards Publication No. TS 2-2003 or later revision.
 - b. One SDLC distribution panel with connectors for 10 SDLC cables.
 - c. Three SDLC cables one each for MMU, Controller, and detector rack BIU.
 - d. The cabinet assembly shall have provision for supporting detection inputs by means of NEMA TS2 BIU method. When using the TS2 BIU method, the detection technology shall use a standard BIU to route detector calls to the controller via the SDLC Port bus.
- 5. Cabinet Mounting.** Mount cabinets as shown on the Plans and per the City of Franklin Standard Details.
- 6. Ventilation.** Unless otherwise specified, provide ventilation as follows:
- a. On all cabinets housing controllers, mount a screened, rain-tight vent, 1-1/2 inches in diameter or larger, on the cabinet top.
 - b. Provide screened or filtered inlet ventilation openings, equal to or greater in area than top vents, located in the bottom or lower back side of Type I and II cabinets or around the lower 8 inches portion of Type III cabinets.
 - c. Construct the vents so as to project within the cabinet no more than necessary to provide for lock nuts and gaskets to retain the vent.
 - d. Locate vents so as to not interfere with the mounting of controller equipment.
- 7. Cabinets with Exhaust Fans.** Exhaust fans shall consist of an electric fan with ball or roller bearings and a capacity of at least 100 cubic feet per minute. Mount the fan in a rain-tight housing attached to the top of the controller cabinet.

The fan shall be controlled by a thermostat having a temperature differential between turn-on and turn-off of 15 °F (-0, +5 °F), adjustable for turn-on through a minimum calibrated range of from 100 °F to 150 °F.

Whenever a fan is to be installed, provide the air inlet filter and filter holder shown in the Standard Details, or approved equal. Internally seal other air inlets. Provide exhaust fans in all cabinets that house controllers, with the exception of flasher controllers.

- 8. Auxiliary Equipment.** With the exception of cabinets used in special applications (Type I and II), provide all cabinets with the following:
- a. Substantial shelves or brackets to support controller and auxiliary equipment as indicated in these specifications.
 - b. Panel for terminals arranged for adequate electrical clearance. Panels should be located in the cabinet as described below:

- Detectors Lower left wall
- AC power Lower right wall
- Auxiliary/police switches Door
- Load switch bay Back wall
- Generator Plug Side Wall

- c. The cabinet shall include an LED light and GFI duplex receptacle which can be used when the main circuit breaker is off.
- d. Control panel assembly consisting of:
 - 1. Power supply connections made to a 30-ampere circuit breaker mounted on the cabinet separate from the signal terminal panel. The circuit breaker shall be a magnetic trip type, having an interrupting capacity of at least 2,000 amperes at 125 volts AC. The circuit shall trip between 101% and 125% of rated load, with an inverse time delay characteristic provided. Instantaneous tripping shall occur at ten times the nominal rating. All controllers shall be internally fused.
 - 2. Service line surge protection as noted in 730.25 of the SPD specifications.
 - 3. Electrical service termination point sized to accept No. 4 AWG copper wire
 - 4. Ground fault receptacle
 - 5. LED cabinet lights shall be dimmable and switchable to reduce glare at night time.
 - 6. Circuit breakers in accordance to the National Electric Code for:
 - (a) Main power input to provide all power associated with normal operation.
 - (b) Flasher power input to provide all power associated with flash operation.
 - (c) Service power to provide power for the lamp and duplex receptacle and cabinet light.
 - 7. Copper ground bus (minimum of 12 positions).
- e. Flasher mechanism independent of controller. The cabinet shall be wired for and include a NEMA flasher mounted on the back panel. All cabinets shall have a two-circuit flasher. The flasher shall have output indicators mounted on the front of the flasher case and shall be rated at a minimum of 15 amperes.
- f. General purpose relays, where required to perform specified functions. All relays external to the controller or appurtenances shall meet NEMA standards. In addition:
 - 1. Flash transfer relays shall be of heavy-duty type and have a minimum contact rating of 10 amperes. Contacts shall be of silver material to reduce contact pitting.
 - 2. Unless otherwise specified, each cabinet shall include six (6) flash transfer relays.
 - 3. Flash transfer relays shall support Flashing Yellow Arrow for Permissive Left-turn movement applications.
- g. Type II, III, IV, and V cabinets, when specified as housing for traffic actuated controllers, with two or more insulated terminal blocks mounted within the housing, one or more for terminating each field wire.
- h. A minimum of 12 available bare ground positions tied to AC Common Return.
- i. Earth (driven) ground tie point to terminate a single No. 4 AWG copper ground.
- j. A 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.
- k. A panel (police subpanel) shall contain the following:
 - 1. A main power switch, which shall be wired to remove all cabinet power when in the Off position.
 - 2. An Automatic Flash switch, which shall be wired as follows:

- (a) The Flash position shall cause the cabinet to provide Flash Operation. The controller shall continue to operate, and Stop Time shall be applied to the controller.
 - (b) Auto/Manual switch to activate Manual Control Enable.
 - (c) Manual control pushbutton switch with self-coiling cord. Cord shall attach to a 2 position terminal strip via fork type connector
 - (d) Upon return from Flashing to Automatic, the controller shall initialize in the Start-Up Display condition as programmed in the controller, typically major road phases.
3. A panel mounted inside the main door shall contain the following switches:
- (a) A technician Stop-Time switch to apply Stop Time to each controller ring.
 - (b) An Interval Advance switch, enabled only by the Stop Time switch, to be momentary pushbutton switch to apply Interval advance to the timer.
 - (c) A Signal On-Off switch, which shall remove the AC power applied to the signal heads for normal operation while the controller continues to operate.
 - (d) Individual phase vehicle and pedestrian detector test switches to be miniature toggle of the On-Off Momentary type to place (only as specified in the plans or by the City):
 - i. No Call - Call provided by detectors
 - ii. Locked detector call
 - iii. Momentary detector call

Insulate or shield switch terminals on back of main cabinet door so that no live parts are exposed.

Leads from the terminal block to the auxiliary door switches shall be no less than No. 18 AWG stranded, with TW plasticized polyvinyl chloride or nylon insulation enclosed in an insulating loom, and shall be of sufficient length to allow full opening of the main cabinet door.

- l. The cabinet shall be wired with the appropriate number of load switches to accommodate vehicular and pedestrian phasing according to plans. At a minimum, cabinets shall include 16 load switch bases. The load switch wiring shall support Flashing Yellow Arrow for Permissive Left-turn Movement applications.
- m. All cabinet wiring shall be neatly routed and labeled, laced and permanently secured. All cable shall be secured to the panel, where practical. There shall be no holes drilled through the cabinet walls to mount panels or secure cables.
- n. All terminals in the cabinet shall be of the barrier type. The following field connector terminals shall be provided:
 - 1. Four (4) signal output positions per load switch bay (R-Y-G-FL).
 - 2. Ten (10) positions per phase for vehicle loop detector harness.
 - 3. One position per phase for pedestrian detector inputs.
- o. Cabinets shall have, at a minimum, SDLC communication between the controller, MMU, Detector Rack, Radar Detector (if applicable) and Video Detection (if applicable).
- p. Cabinets shall have two 4-way electrical outlet assemblies (Non GFI) that has 120 VAC from the OUTPUT side of the Main Power Surge unit for pluggable equipment.
- q. Cabinets shall support Flashing Yellow Arrow for Permissive Left-turn Movements applications.
- r. All cabinets shall be supplied with a Malfunction Management Unit (MMU) and shall meet at a minimum, the following requirement:

NEMA TS2 Malfunction Management Unit NEMA TS 2 2016

The manufacturer must supply certification of the conformance to the above requirements at the time of the bid.

According to NEMA TS2 the MMU shall be able to detect the presence of voltage on conflicting on conflicting field connection terminals, the absence of proper voltages on all the signal field connection terminals of a channel, and shall be capable of monitoring for the presence of satisfactory operating voltages within the Controller Unit (CU) and the MMU itself. The MMU shall be able to operate as a Type 16 with sixteen channels or as a Type 12 with twelve channels (compatible with NEMA TS1 cabinets).

The MMU shall have an Ethernet port configurable by the City of Franklin to be on the City's network.

The MMU shall be able to be configured for Flashing Yellow Arrow operation.

The MMU shall have fault logging features that include at a minimum:

- Date of Fault
 - Time of Fault
 - Fault Condition
 - Power Failure
- Faults and logs shall be stored in non-volatile memory for remote user retrieval

The MMU shall be an EDI – MMU2-16LEip Enhanced NEMA Signal Monitor w/ Ethernet Port or approved equivalent.

- s. The cabinet shall include an Opticom Auxiliary Interface Panel (AIP) and Opticom GPS Radio (3101) mounted to the side of the cabinet
- t. A generator plug with automatic hot swap bypass switch shall be included with the cabinet and mounted on the side of the cabinet. The bypass shall prevent utility back feed and fail-to-line in the event of generator or Uninterruptable Power Supply (UPS) failure.

9. Enhanced Operational Features.

- a. When shown on the Plans, or specified in the Special Provisions, supply certain enhanced operational features of controllers. When required, these inputs and outputs shall be accessed to the controller by a dedicated fourth (or "D" Connector). Provide a connector of a type as determined by the manufacturer, and that meets the following requirements:
- b. This connector shall not be mateable to any other connector in the cabinet.
- c. All operating voltages in this connector shall be NEMA DC level voltages.
- d. No special operating features shall enter or exit the controller on any NEMA pin designated as "Spare" or "Future."
- e. When the "D" connector is not connected to the controller, the cabinet facility shall operate as a standard NEMA cabinet facility with no operational loss of standard NEMA features.
- f. If the "D" connector is used as the input source for Pre-Emption operation, wire the cabinet facility so that the cabinet facility will NOT perform any operation other than FLASH unless the "D" connector is terminated at the correct termination point and all cabinet features including Pre-Emption are operational.

730.27 Auxiliary Equipment for Traffic Signal Controllers

Furnish and install the following auxiliary equipment in each cabinet for traffic actuated controllers.

A. The Cabinet shall include a TS2-1 to TS2-2 power adaptor cable (A cable).

B. Load Switches

Provide each cabinet complete, with the necessary number of NEMA load switches and Flash Transfer relays necessary to affect the specified signal sequence and phasing. Load switches shall:

1. Meet NEMA standards.
2. Have front-face mounted LED indicators to indicate the “On” condition of both the Input and Output circuits.
3. Use replaceable “cube” type circuitry or encapsulated discrete component construction. No unencapsulated discrete component constructions are acceptable.

Load switches shall be PDC SSS86I/O.

C. Time Clock Switches

Where shown on the Plans, provide time clock switches of solid state circuitry, continuous duty, with a 7-day cycle clock operating from the 120-volt AC service line. Provide switching for a minimum of one independent output and ensure the time of day selection is adjustable to within 1 minute of the desired time. Provide a battery backup system that can maintain time keeping and memory a minimum of 24 hours after power interruption. Furnish an omitting device as an integral part of the time switch to allow the switching operation to be skipped for any preselected day or days of the week. The time clock shall automatically compensate for daylight savings time changes. When the time clock is supplied as an internal component of the controller, supply the clock feature to provide for the selection of Maximum Green II on time of day, day of week, week of year basis. Time clocks shall meet NEMA environmental specifications.

When required in the traffic signal plans, the auxiliary equipment listed below shall meet the following requirements:

A. Uninterruptable Power Supply (UPS)

The uninterruptible battery back-up system for the traffic signal cabinet shall have a programmable digital display with remote monitoring capabilities, including UPS fail, AC fail, on battery and low battery. The UPS shall be a double conversion, power conditioning unit to fully power the traffic signal, including full signal and cabinet operation, in the event of a power failure for a minimum of 2 hours. The traffic signal shall be able to go into ‘flash’ condition for an additional 2 hours for a minimum UPS backup power requirement of 4 hours total. The UPS shall be able to accommodate an average system operating demand of 450 watts with a peak of 750 watts (usually found under all-red traffic signal operation conditions).

UPS assemblies should include off-the-shelf deep cycle Lithium Ion Phosphate batteries or approved equivalent. Loss of utility power, transfer from utility power to battery power, and transfer back to utility power must not interfere with normal operation of connected equipment. In the event of UPS failure or battery depletion, connected equipment must be energized automatically upon restoration of utility power. Removal and replacement of the UPS must not disrupt the operation of the equipment being protected.

All harnesses necessary to connect and operate the system must be included. All connectors must be keyed to prevent improper connection.

UPS assemblies shall be installed in accordance with the manufacturer’s recommendations.

An UPS operation and maintenance manual shall be provided in the cabinet where the UPS is installed with cabinet wiring schematics, electrical interconnection drawings, parts layout and parts lists.

The UPS shall include a manufacturer's warranty covering defects for a minimum of three years (5 years for the external batteries) from the date of final equipment acceptance. The warranty must include provisions for providing a replacement UPS within 10 calendar days of notification for any UPS found to be defective during the warranty period at no cost to the maintaining agency.

The UPS shall have communications capability with the City's current TCP/IP Ethernet network for remote monitoring. Should the UPS not have an Ethernet RJ45 communication port compatible with the City's network requirements, a device with the capability to support IP/Ethernet communications to the UPS from the City of Franklin TOC shall be provided.

Operating temperature range: -30° F to 165° F

The UPS batteries and controller must be able to fit into the TS2 Type 1 cabinet, as specified.

B. Communications

Ethernet switches shall be a hardened, three 10/100/1000 Base-TX, with two Gigabit combo ports that utilize SFP modules for fiber and twisted pair copper communication mediums. The switch shall offer centralized and convenient management through a windows-based utility. The module shall support transmission utilizing Category 5e cable or better, multimode, or single-mode fiber. The module shall support the Ethernet data IEEE 802.3 protocol using Auto-negotiating and Auto-MDI/MDI-X features. The switch shall be specified, approved, and accepted by the City of Franklin Information Technology (IT) Department.

C. Fiber optic cables

Single-mode type cable shall be between 8-9 μm core diameter, with at least 12 fibers per cable unless otherwise specified. A fiber optic drop cable shall be a minimum of 6 fibers (each type) and be spliced into the trunkline in a splice enclosure either aerially or in a pull box. 50ft. of slack shall be provided, either lashed to a span aerially, or coiled in a pull box for underground installations. Termination panels shall be provided with sufficient size to provide for a neat installation, and enough panel space to accommodate the specified number of fibers for termination. ST connectors shall be used unless otherwise specified. Any necessary jumpers shall be provided for installed equipment.

MISCELLANEOUS TRAFFIC SIGNALS**730.28A Flashing School Signals**

When shown on the Plans, provide flashing school signals compatible with the City of Franklin's current school flashing system and that 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 shown on the Plans. Sign colors shall conform to the MUTCD and be constructed of materials complying with these specifications.
2. The two LED lenses shall be yellow in color and a minimum of 12 inches in diameter. The LED lenses shall be part of a weather-proof and water-tight optical unit. The LED lenses shall meet the same requirements for vehicular signal head LED lenses. Mount the lenses in the sign using a molded endless rubber gasket with the sign being mounted to the signal case.

3. Provide a two circuit type flasher unit 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.
4. Wire the unit for external circuits.
5. The signal shall be actuated by time switch meeting **730.27**. Locate the timing device in a remote mounted control cabinet.
6. Where an illuminated speed limit indication is shown 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.

In addition, the Time Clock Unit/Switch used for Flashing School Signals shall be a programmable module that allows a user to define the time and day that the school speed zone flasher assembly will initiate and terminate flashing operation. The module shall be installed within the pole-mounted signal cabinet provided as part of project. The time clock shall be compatible with the cabinet's wiring relays and termination panels and the battery power supply system. The time clock switch provided shall also have the following features/capabilities outlined below:

1. Daylight Savings Time shall be a user-programmable setting, in addition to having automated compensation per TDOT specifications.
2. The unit shall provide a minimum 12-character, multi-line alpha-numeric LCD back-lit display capable of displaying all programming parameters.
3. The unit shall be capable of being programmed manually (using an integral keyboard pad) or programmed externally using an optional software program via a laptop computer and cable connection (compatible software program is a separate and distinct item from the time switch unit, and if required, will be separately specified and noted in list of estimated project quantities).
4. Unit shall provide automatic Leap Year compensation.
5. The time clock switch shall be capable of up to minimum 24-hours of capacitive back-up operation, 48 hours desirable, in the event of power interruption.
6. Unit shall be compatible with the supplied solar powered power system / battery unit
7. Time clock switch shall be capable of being programmed for one (1) Normal / Main program, and an additional minimum of 12 Exception periods /programs allowing holiday, vacation and custom skip plans. The exception programs will allow for the Normal / Main program to be skipped or allow for flasher operation on alternative schedules (i.e. early release days, summer school, etc).
8. Unit shall conform to TDOT standard specification subsection 730.27 – Auxiliary Equipment for Traffic Actuated Controller – Time Clock Switches except as superseded herein.
9. Unit shall have non-volatile program memory to allow retention during power loss.

730.28B Solar Power Flashers

When required, the solar power flasher equipment listed below shall meet the following requirements:

1. Solar panel and mounting equipment shall be installed on cantilever pole shaft as illustrated on layout detail sheet and as directed by manufacturer instructions.

2. Solar power unit assembly shall include all required mounting equipment, wiring/cables, battery supply, battery charging unit and other ancillary equipment necessary to operate the solar panel and properly charge the battery. The photovoltaic array shall include mounting bracket assembly to permit adjustment of the array to optimal sun exposure. The photovoltaic module shall be mounted and aligned per manufacturer recommendations to maximize solar exposure.
3. Battery unit shall meet manufacturer specifications required to operate and power L.E.D. signal displays and continuous time clock switch operation. Battery shall be compatible with cabinet equipment, including the time clock switch and the flasher signal displays. Battery unit shall meet minimum environmental and performance specifications required for system operation as recommended by solar panel and time clock switch manufacturers.
4. Solar panel and battery supply shall be of a size and power rating necessary to provide required power to time switch clock and flasher signal displays. Obtain the power load requirements from the solar power equipment manufacturer and provide as required. On a typical school day, it should be expected that the flasher system will operate up to four (4) hours per day with the time clock continuously operating to maintain its clock timer. Provide a solar system sizing report from the manufacturer indicating the power supply requirements of the proposed system required to meet the expected power demand.
5. The photovoltaic modules shall be warranted for a minimum of five (5) years from date of installation.
6. The battery system shall be a gelled-electrolyte type battery with capacity to provide a minimum of five (5) days continuous operation of the flasher assembly without charging. Batteries shall be field replaceable. Batteries shall have prorated warranty of a minimum of five (5) years from date of installation.

730.28C Portable Traffic Signals

Portable Traffic Signals (PTS) consists of furnishing, installing and configuring a complete PTS system that may be used in construction zones or in other temporary signal locations. The work will be at various sites throughout the state of Tennessee and will consist of providing all labor, materials, equipment and incidentals necessary to make functional the PTS in accordance with these specifications.

The PTS shall be trailer or cart mounted units that provide for easy transportation and quick setup and deployment. There shall be 2 unit options and each unit shall be self-contained.

1. Type 1 units are typically used for long term projects (i.e. projects 5 days or longer in duration) and shall include 2 signal heads per trailer with an upper signal head mounted on an overhead mast arm that can be extended over the travel lane, and a lower signal head mounted on the vertical upright of the trailer.
2. Type 2 units are typically used for short term projects (i.e. projects 4 days or shorter in duration) and shall include 1 signal head that is mounted on the vertical upright of the trailer or cart. Cart-mounted units shall meet the requirements of and be listed on the Department's QPL or Standard Drawings. If the project duration is extended beyond 4 days, then Type 1 units should be substituted in lieu of the Type 2 units for all PTS within the signal system.

The PTS shall be MUTCD Compliant and utilize standard ITE signal heads, and adhere to the ITE Specifications and Standards for Vehicle Traffic Control Signal Heads, Light Emitting Diode (LED) Circular Signal Supplement. The unit shall be solar powered and communicate via a wireless or hardwire connection. The unit shall include all the major components listed below or be able to perform the functions of these components. The major components of the unit shall include but are not limited to the trailer or cart, telescoping mast arm (on Type 1 units only), signal head(s) and back plates, traffic signal controller with operating software, solar charging system with batteries, input and output devices, flasher units, conflict monitor, relays, communications system and other equipment required for the safe operation and installation of the unit.

The PTS signal heads and all applicable components of the PTS shall meet the physical display and operational requirements of conventional traffic signals as specific in the MUTCD.

1. For Type 1 units, each unit shall contain 2 signal heads with an upper signal head mounted on an overhead mast arm that can be extended over the travel lane with a minimum clearance of 17 feet measured from the bottom of the signal head unit to the road surface. The lower signal head shall be mounted to the vertical upright of the trailer at a minimum height of 8 feet from the bottom of the signal head unit to the road surface. The signal heads shall also include black back plates that can be easily removed. The signal heads shall have the ability to be rotated 180 degrees to face in the opposite direction and shall have the ability to rotate and lock in approximately 10 degree increments to position the signal head for the optimum visibility to motorists.
2. For Type 2 units, the signal head of the unit shall be mounted to the vertical upright at a minimum height of 8 feet from the bottom of the signal head unit to the road surface. The signal head shall also include black back plate that can be easily removed. The PTS shall be easily rotated to position the signal head for optimum visibility to motorists.

The PTS shall include a solid-state controller with operating temperature range of -40°F to +180°F and compliance with NEMA TS-5 Performance Standard. The controller or programming module shall have an easy to read front panel indicator display. The display shall be backlit and have the capability to facilitate programming and display the currently operating program for each vehicular approach. The controller shall be capable of operating the PTS system in a fixed time, traffic actuated, or manual control mode. Each PTS in a connected system shall have the capability to serve as either the master or slave signal. Each PTS shall include a Conflict Monitor Unit (CMU), or Malfunction Management System (MMS) to ensure phase conflicts do not exist during operation.

1. A minimum of 5 automatic time-of-day timing plans within a 24-hour period should be available in fixed time mode. The operating system should have the ability to control a minimum of 4 traffic phases with programmable cycle time adjustments and user adjustable red, amber, minimum green and maximum green times. The operating system shall also have the capability of facilitating standby modes of red, red flash and yellow flash.
2. The system shall also have the ability to operate in vehicle actuation mode when vehicle detection detectors are used. The operating system shall have the capability to allow the PTS to be connected to and controlled by a standard NEMA controller.
3. The system shall have the capability to be configured and controlled remotely using a handheld wireless remote control with the capability of being operated at a distance up to ¼ mile from the master.
4. The system shall have the capability of remote monitoring for reporting, at a minimum, signal location and status, battery voltage and system defaults. The remote monitoring shall have capability to alert designated individuals if a fault condition occurs.
5. The operating system shall include password protection to prevent unauthorized programming.

The PTS shall communicate with all other PTS within the signal system via license-free wireless 900 MHZ radio link communications. The radio units shall maintain communications at a minimum distance of 1 mile. The radio system shall conform to the applicable Federal Communications Commission (FCC) requirements, including FCC 90.17, and all applicable state and local requirements. The PTS shall be in direct communication at all times either by wireless or hardwire connection to provide for the required conflict monitor.

The system shall also have the ability to operate in vehicle actuation mode when vehicle detection detectors are used. For Type 1 units, the PTS detector shall be a high-definition, multi-beam, microwave radar stop bar detector for each vehicular approach. The Type 1 radar detector shall have a minimum range of 140 feet and shall be mounted at a minimum height of 17 feet measured from the top of the road surface. For Type 2 units, the PTS detector shall be a

radar detector for each vehicular approach. The Type 2 radar detector shall have a minimum range of 140 feet and shall be mounted and have complete radar detection functionality at a minimum height of 8 feet measured from the top of the road surface.

The PTS shall be equipped with a solar power array, charging unit and battery system. For Type 1 units, the number and size of batteries shall be sufficient to operate the signal for a minimum of 21 days at 70 degrees without additional charging or assist from the solar array. An on-board battery charger shall be compatible with both the solar array and with a 120V AC power source. The solar panel array shall provide for a minimum of 440 watts of solar collection capability. For Type 2 units, the PTS shall have batteries sufficient to operate the signal for a minimum of 5 days at 70 degrees without additional charging or assist from a solar array. All instrumentation for the electrical system and battery compartment shall be mounted in a lockable weatherproof enclosure. Solar panels shall be secured to the mounting brackets for theft prevention. All wiring for the unit shall be protected against weather and damage.

The trailer or cart, and all mounted components, shall conform to the wind loading requirements (90 mph minimum) as described in the AASHTO Standard Specifications for Highway Signs, Luminaries and Traffic Signals. The wind load calculations shall be completed by an independent third-party, and stamped by a U.S. Registered Professional Engineer. The trailer or cart shall be made of structural steel and shall include 4 leveling/stabilizer jacks capable of lifting the trailer or cart a minimum of 6 inches. The trailer or cart shall be equipped with a hydraulic or electric lift system sufficient for 1 person to be able to raise and lower the vertical upright and/or horizontal mast arm to and from the operating position. For Type 1 or 2 units, the trailer or cart shall be equipped to provide legal and safe transport on the public highway system at speeds up to 55 mph. All exterior metal surfaces, except signal heads and back plates, shall be powder-coat painted highway safety orange.

The PTS work shall meet the following general requirements:

1. Be responsible for locating the PTS in the appropriate location based on MUTCD and ITE standards for visibility to motorists and for safe operation.
2. Be responsible for providing all hardware, software, communications equipment and licenses to operate a complete PTS system.
3. Be responsible that all PTS equipment is installed according to the manufacturer's recommendations including wireless or hardwire connections.
4. Be responsible for transport, setup, configuration, operation and monitoring of the PTS throughout the entire project. The Engineer shall approve all timing and settings that are used for operation of the signal.
5. As directed by the Engineer, it may be necessary to relocate the PTS during the project. The cost of the relocation shall be included in the PTS price bid.

DETECTORS

730.29 Detectors

Provide detectors, of the type shown on the Plans, to actuate signal phases of traffic actuated controllers. Provide ample lightning protection to provide effective defense against high transient voltages caused by lightning discharges or from other sources. The lightning protection unit must withstand repeated 400-ampere surges on a 9 x 20 microsecond waveform. Also, the unit must be a two-stage device capable of clamping a minimum of one hundred 300-ampere surges to 25 volts within 40 nanoseconds for surge applied across the two detector leads.

A. Inductive Loop Detection System

Inductive loop detector units (loop amplifiers) shall meet at a minimum, the following requirement:

NEMA TS2 Inductive Loop Detector Units NEMA TS 2 2016

Detector loops shall be installed in accordance with TDOT Standard Drawing T-SG-3, standard notes and details of detector loops

Loop amplifiers shall be of the multi-channel, rack-mounted type meeting the standards of the latest NEMA TS2 revision for detector rack configuration. The number of detector channels shall be as specified in the plans. The front of the rack-mounted detector shall provide an LCD display for programming and monitoring.

The rack-mounted loop amplifiers shall be powered by a 24V DC power supply external to the controller unit as defined in NEMA TS-2 Section 5.3.5. All loop amplifiers shall be of the type to provide both "Extended" and "Delayed" outputs.

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:

1. Sense any legal motor vehicle traveling at speeds up to 65 miles per hour.
2. Have both a "Pulse" and "Presence" Output:
 - a. Pulse output shall generate an output of 125 ±25 millisecond output for each vehicle entry.
 - b. Presence output shall provide a continuous output for up to 60 minutes as long as a vehicle is within the detection zone.
3. Provide at least four user selectable sensitivity ranges.
4. Be supplied with at least three frequency ranges for crosstalk minimization.
5. Have a front-face mounted indicator to indicate active output of the internal relay. This indicator shall indicate the presence of:
 - a. Normal Output
 - b. Delayed Output
 - c. Extended Output
6. Have a front-panel mounted "Reset" switch that when pressed shall cause the unit to completely re-tune itself.
7. Have Delayed or Extended timing features with the following ranges:
 - a. Delayed output of 0 to 30 seconds in 1-second increments.
 - b. Extended output of 0 to 10 seconds in 1/4-second increments.
8. 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.
9. Provide output by a mechanical relay, which shall be "off" to provide an output.
10. Have all delay functions wired to the associated plan phase green to inhibit that function during controller phase green.
11. Be able to operate with loop lead-in lengths of at least 2,000 feet. All loop head and homerun wire to be continuous with no splices within the roadway.

Comply with the details of the detector loop installation as shown on the Plans or Standard Drawings.

B. Video Detection System (VDS)

When specified in the plans, the equipment shall consist of all items necessary to provide a complete functional video detection system that process images and provide detection outputs to the traffic signal controller. The VDS shall be capable of the following:

1. Be capable of NEMA TS2 operation.
2. Be waterproof and weather resistant.
3. Provide user-defined detection zone programming via a graphical user interface (GUI) and any necessary equipment for future programming. The configuration database shall have the ability to be stored on removable data storage external to the video card.
4. Display programmable detection zones and detection activations overlaid on live video inputs. It shall detect vehicles in real time as they travel across each detection zone.
5. Have a minimum of 24 programmable detection zones per camera.
6. Shadow rejection without special hardware.
7. Non-impaired operation under light intensity changes.
8. Maintain operation during various weather conditions (e.g. rain, fog, snow).
9. Anti-vibration, 5% rejection based on image change.
10. Ability to select direction of flow parameters.
11. Ability to properly detect directionally.
12. Ability to configure presence, pulse, extend and delay outputs.
13. Ability to set up a minimum of six detection zones per camera view to count the number of vehicles detected and stores the information for retrieval.
14. Variable focus providing a minimum of 4 to at least 40 degree horizontal field of view.
15. Store detection zones in non-volatile memory.
16. Have no splices between the processors and the cameras.
17. Provide LED indicators to show active detection.
18. Have an internal heater to assure proper operation of the equipment during low temperatures.
19. Have surge ratings as set forth in NEMA specifications.
20. Have a two-year warranty and updates of all software shall be available without charge during the warranty period.

VDS shall be of a single 4K resolution, fish-eye type camera equivalent to Miovision SmartView 360 and components as listed below:

- a. SmartView 360 camera
- b. SmartSense cabinet interface device
- c. SmartLink network device

C. Radar Vehicle Detection System (RVDS)

When specified in the plans, the equipment shall consist of all items necessary to provide a complete functional RVDS that process high-definition, multi-beam radar electromagnetic waves and provide detection outputs to the traffic signal controller.

RVDS shall be capable of NEMA TS2 operation.

The RVDS shall consist of the following components:

1. Radar sensor (1)
2. Detector rack interface module (1)
3. Power and surge protection panel or module (1) (cabinet interface devices that combine one or more of the above components shall be acceptable as well).
4. All associated equipment required to setup and operate in a field environment including software, serial and ethernet communication ports, cabling, electrical connectors and mounting hardware.

The RVDS shall be capable of the following:

1. The RVDS shall be able to operate in all types of weather conditions including: rain, snow, sleet, ice, fog and windblown dust.
2. Lightning and surge protection will be provided for power connections and communications links to the radar RVDS.
3. Provide a “fail safe” operation that triggers when communication between the radar vehicle sensor and the interface module is broken. Contact closure from the interface module will occur on all programmed detector channels associated with the affected radar sensor when the failsafe is triggered and will remain in this state until communication is re-established between the interface module and the radar vehicle sensor.
4. Comply with all applicable Federal Communications Commission (FCC) requirements. The manufacturer will provide documentation of compliance with FCC specifications.
5. Shall maintain frequency stability without the use of manual tuning elements by the user.
6. Shall provide a minimum of 4 separate RF channels selectable by the user to avoid interference with other devices working on the same frequency.
7. The communication port(s) shall support a communication speed that will not introduce excessive latency between when a vehicle is detected and the contact closure in the traffic signal cabinet.
8. The interface modules that utilize the detector rack must operate at 12V or 24V DC. Shelf mounted interface modules must operate within a range of 89V to 135V AC, 60 Hz single phase. Power to the RVDS radar sensor must be from the transient protected side of the AC power distribution system in the traffic control cabinet in which the RVDS is installed.
9. RVDS documentation shall include a comprehensive user guide as well as quick reference guide(s).
10. Shall have the ability to configure presence, pulse, extend and delay outputs.

RVDS shall be above-ground radar presence detector equivalent to Wavetronix SmartSensor radar devices, equivalent to the City’s current RVDS, as listed below:

- a. Stop Bar Presence Detector – Wavetronix SmartSensor Matrix SS-225
- b. Advanced Detection – Wavetronix SmartSensor Advance SS-200V
- c. Mid-block Detection and Monitoring – Wavetronix HD
- d. Cabinet Interface Device – Wavetronix Click 656
- e. Detector Rack Cards – Wavetronix Click 112/114
- f. Serial to Ethernet – Wavetronix Click 301

D. Wireless Magnetometer Detection System (WMDS)

When specified in the plans, the equipment shall consist of all items necessary to provide a complete functional wireless magnetometer detection system that process changes to earth magnetic field and provide detection outputs to the traffic signal controller.

WMDS shall be capable of NEMA TS2 operation.

The WMDS shall consist of the following components:

1. In-pavement sensors
2. All wireless communication equipment needed to establish communication links to the controller cabinet.
3. Interface modules compatible with NEMA TS-2 V2.06b cabinet detector rack.
4. Surge protection for the WMDS and system software for set-up and monitoring of the WMDS.

The WMDS shall be capable of the following:

1. Detecting a variety of vehicle types including motorcycles, automobiles and large trucks. The system must allow the user to select sensitivity levels that adjust the amount of hysteresis to the magnetic field needed to achieve contact closure to the assigned detector channel. Magnetometer sensitivity level adjustments must allow for different levels of vehicle detection.
2. The ability to configure presence, pulse, extend and delay outputs.
3. WMDS equipment failure such as: the sensor, communications link, access point radio, repeater radio (if used) or interface module, shall result in constant vehicle call "fault state" on the affected detector channel to the traffic controller.
4. Detection accuracy must be comparable to properly operating inductive loops.
5. Provide real-time vehicle detection (within 150 milliseconds (ms) of vehicle arrival). Once detection is achieved by the sensor, the traffic controller must receive contact closure to the assigned detector channel within the 150 ms time frame.
6. The in-pavement sensor must operate on batteries without the need for underground power or communication cable connections to the unit.
7. The average operating life span of the sensor under battery power must be a minimum of 10 years.
8. The interface module must provide 2 or 4 detector channels. Sensors must be assignable to the available detector channels on the interface module using software provided with the WMDS.
9. The front face of the module shall identify detector channel 1 and detector channel 2. Each must use an LED to indicate contact closure on the channel. When vehicle detection is achieved, the LED will be on and contact closure applied to the detector channel. During periods of no vehicle detection the LEDs will be in an off state and no contact closure will be applied to the detector channel.
10. The interface module will use an LED indication to indicate a "fault state" with the WMDS. When the fault state is active contact closure will be applied to the appropriate detector channel.

The WMDS shall be equivalent to Sensys detection of the type and parts listed below, consistent with the City's current WMDS:

Sensys VSN240-F-2 Flush-Mount Sensor
Sensys FLEX-RPT3-SLR Solar Repeater
Sensys FLEX-ANT-2 Long Range External Antenna
Sensys FLEX-ANT-1 Standard External Antenna
Sensys FLEX-ISOL-M Isolator Module
Sensys APCC-SPP Digital Radio
Sensys FLEX-CTRL-M-E Control Module, Enhanced
Sensys FLEX-CONN-M Stand-Alone Unit

E. Pedestrian Push Buttons

Where shown on the Plans, furnish and install pedestrian push buttons of substantial tamper-proof construction. They shall consist of a direct push type button and single momentary contact switch in a cast metal housing. Operating voltage for pedestrian push buttons shall not exceed 24 volts.

Provide a weatherproof assembly, constructed to prevent electrical shocks under any weather condition.

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.

Unless otherwise specified, install the push button and sign on the crosswalk side of the pole.

Pedestrian push buttons shall have a transient protection that meets NEMA specifications.

Accessible pedestrian push buttons shall be in accordance with PROWAG requirements. Submit accessible pedestrian push buttons to TDOT and the City of Franklin for review and approval.

The pedestrian push buttons shall be equivalent to the Polara iNavigator system, consistent with the City's current pedestrian detection.

F. Emergency Vehicle Priority Control System

The City of Franklin uses a Global Traffic Technologies GPS Opticom emergency vehicle priority control system in conjunction with the traffic signal installation. To ensure priority control system integrity, operation and compatibility, all components at all intersections shall be from the same manufacturer. Priority control shall be provided on the applicable approaches of the intersection as indicated on the plans. Intersection detection equipment will consist of Model 3100 GPS Radio Unit containing a GPS receiver with antenna and a 2.4 GHz spread spectrum transceiver with antenna mounted atop of the signal cabinet, both connected to an Opticom Model 764 Multimode Phase Selector located in the intersection controller cabinet. The multimode phase selector shall be installed in a 1045B Opticom Card Rack or Opticom Model 760 card rack. Preempt panel shall be wired for R/R F/H Opticom

MISCELLANEOUS**730.30 Internally Illuminated Street Name Signs**

Internally illuminated Light Emitting Diode (LED) signs shall be Temple Edge-Lit, Transportation Control Systems Britelite Edge Lit, or approved equal. This specification shall govern for LED street name signs which are rigid bracket-attached to traffic pole shafts and/or mast arms. All materials used in fabrication shall be new and of good quality.

A. Sign Dimensions

The LED internally illuminated street name sign shall be capable of being constructed in standard widths from 24-120 inches in length, according to the construction plans. The height of the signs shall be 22 inches to accommodate 12-inch upper case letters / 9-inch lower case letters and 2.5-inch clearance from the vertical sides. Street name legend shall be a mixed upper and lower case letters, with a superscripted extension.

B. Sign Sheeting

Sign shall have a single side message as shown on the design sheets. The message should be bright white letters. The background shall be a green 3M™ Electrocut™ film, Avery Dennison film, or approved equal.

The Manufacturer/Vendor shall supply shop drawing submittals on the fixtures, sign, sign message and mounting hardware. Where the Manufacturer/Vendor has not previously supplied the item to the City of Franklin that Supplier shall provide a full-size physical prototype of all equipment to the City for review and approval.

C. Hardware

The sign shall be rigid-mounted to a pole shaft or mast arm. The method of mounting shall be by banding. Unless otherwise shown on the plans or required in this specification, all fasteners and screws in or on the fixture shall be stainless steel type 302 or 305, brass or aluminum. All steel nuts, bolts, and hardware for sign attachment shall be stainless steel type 302 or 305.

The plans are to show the location on the mast arms for the clamp-on street signs, when required, as well the location and details for the wire entrance. Offset mounting brackets with clamps and adapters shall be attached at two-foot spacing on the back side panel for use of Band-It material, Uline material, or approved equal to rigidly mount the sign to the mast arm. The sign bracket itself shall clamp the top and bottom frame of the sign. The adapters shall swivel around the mid-height level of the sign, and be lockable to allow for leveling of the sign.

All wiring connections within the sign fixture shall terminate through an U.L. approved junction box.

All conductors inside the sign fixture and on the load side of the power source shall be U.L. listed appliance material (no smaller than #14 AWG) stranded copper wire with thermoplastic insulation.

730.31A Fiber Optic Cable (OSP)

All outside plant trunk cables used in the project shall be stranded loose tube design. Drop cables shall be central core or stranded loose tube design. The cable configurations shall be dictated by the particular communication path, data rate, & distance of the optical path.

Cable configurations required shall be displayed in the design plan set.

1. General Considerations

The cable shall meet all requirements stated in this specification. The cable shall be a listed product of the United States Department of Agriculture Rural Utilities Services (RUS) 7 CFR1755.900 and the ANSI/ICEA Standard for Fiber Optic Outside Plant Communications Cable, ANSI/ICEA S-87-640-1992.

The cable shall be new, unused, and of current design and manufacture.

2. Fiber Characteristics

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

Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding. The fiber shall be matched clad design.

SINGLE-MODE: The single-mode fiber utilized in the cable specified herein shall conform to the following specifications:

- a. Typical Core Diameter: 8.3 μm .
- b. Cladding Diameter: 125.0 \pm 1.0 μm .
- c. Core-to-Cladding Offset: $< \square 0.8 \mu\text{m}$.
- d. Cladding Non-Circularity: $\square \square < 1.0\%$. Defined as: $[1 - (\text{min. cladding dia.} / \square \square \text{max. cladding dia.})] \times 100$
- e. Coating Diameter: 245 \pm 10 μm .
- f. Colored Fiber Diameter: nominal 250 μm .

- g. Attenuation Uniformity- No point discontinuity greater than 0.10 dB at either 1310 nm or 1550 nm.
- h. Attenuation at the Water Peak- The attenuation at 1383 ± 3 nm shall not exceed 2.1 dB/km.
- i. Cutoff Wavelength- The cabled fiber cutoff wavelength (λ_{ccf}) shall be < 1250 nm.
- j. Mode-Field Diameter: 9.30 ± 0.50 μm at 1310 nm 10.50 ± 1.00 μm at 1550 nm
- k. Zero Dispersion Wavelength (λ_0)- 1301.5 nm $< \lambda_0 < 1321.5$ nm.
- l. Zero Dispersion Slope (S_0)- < 0.092 ps/(nm²km).
- m. Polarization Mode Dispersion < 0.5 ps/sq.rt. km

The coating shall be a dual layered, UV cured acrylate applied by the fiber manufacturer.

The coating shall be mechanically strippable without damaging the fiber.

3. Fiber Specification Parameters

Required Fiber Grade - Maximum Individual Fiber Attenuation for single-mode fibers shall be 0.40dB/km @ 1310nm, 0.30dB/km @ 1550.

The maximum dispersion shall be ≤ 3.2 ps/(nm_{km}) from 1285 nm through 1330 nm and shall be ≤ 18 ps/(nm_{km}) at 1550 nm.

4. Specifications for Outdoor Trunk Cables

Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be 3.0 mm.

Each buffer tube shall contain up to 12 fibers.

The fibers shall not adhere to the inside of the buffer tube.

Each fiber shall be distinguishable from others by means of color coding in accordance with EIA/TIA-598-A, "Optical Fiber Cable Color Coding." The ink for coloring fibers shall be UV cured; no thermal inks shall be used in the coloring process.

Buffer tubes containing fibers shall also be color coded with distinct and recognizable colors in accordance with EIA/TIA- 598, "Optical Fiber Cable Color Coding."

- a. Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 1 mm.
- b. For dual layer buffer tube construction cables, standard colors are used for tubes 1 through 12 and stripes are used to denote tubes 13 through 24. The color sequence applies to tubes containing fibers only, and shall begin with the first tube. If fillers are required, they shall be placed in the inner layer of the cable. The tube color sequence shall start from the inside layer and progress outward.

In buffer tubes containing multiple fibers, the colors shall be stable during temperature cycling and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.

The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrink back requirements of 7 CFR 1755.900.

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

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

Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.

Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or "SZ", stranding process. Water blocking yarn(s) shall be applied longitudinally along the central member during stranding.

For single layer cables, a water blocking tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The tape shall be held in place by a single polyester binder yarn. The water blocking tape shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter. Dual layer cables shall be water blocked in a similar fashion.

Two polyester yarn binders shall be applied contra helically with sufficient tension to secure the buffer tube layer to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dielectric with low shrinkage.

The cable shall contain at least one ripcord under the sheath for easy sheath removal.

Tensile strength shall be provided by high tensile strength aramid yarns and/or fiberglass yarns.

The high tensile strength aramid yarns and/or fiberglass yarns shall be helically stranded evenly around the cable core.

The cable shall be sheathed with medium density polyethylene. The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking tape. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

The jacket or sheath shall be free of holes, splits, and blisters.

The cable jacket shall contain no metal elements and shall be of a consistent thickness.

The cable jacket shall be marked with "Manufacturer Optical Cable," sequential foot markings, year of manufacture, fiber count and fiber types, EX (72f, 36 sum, and 36 mm 62.5/125). The actual length of the cable shall be within $-0\pm 1\%$ of the length markings. The marking shall be in contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm.

The maximum pulling tension shall be 2700 N (608 lbf) during installation (short term) and 890 N (200 lbf) long term installed.

The shipping, storage, and operating temperature range of the cable shall be -40degreeC to $\pm 70\text{degreeC}$. The installation temperature range of the cable shall be -30degreeC to $\pm 70\text{degreeC}$.

5. Specifications for Drop Cable (to Controllers, VMS, Camera locations, etc.)

The City of Franklin specifies that the Fiber Connections Inc. "Gator Patch ITS Drop Cable" Model # GP20L006FRB-xx-1 shall be used in each location (xx is cable length to splice pull box plus additional 20 feet slack for splicing in meters), Z Stack Pre-Terminated All-purpose Patch Panel, or approved equal. This unit is the fiber termination panel to be mounted in the cabinet and the attached drop cable is run to the trunk cable splice pull box where a mid-span splice will be made.

6. General Cable Performance Specifications for OSP cables

When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components," the change in attenuation at extreme operational temperatures (-40degreeC to \pm 70degreeC) shall not exceed 0.2 dB/km at 1550 nm for single-mode fiber and 0.5dB/km at 1300 nm for multimode fiber.

When tested in accordance with FOTP-82, "Fluid Penetration Test for Filled Fiber Optic Cable." a one meter length of unaged cable shall withstand a one meter static head or equivalent continuous pressure of water for one hour without leakage through the open cable end.

When tested in accordance with FOTP-81, "Compound Flow (Drip) Test for Filled Fiber Optic Cable", the cable shall exhibit no flow (drip or leak) of filling or flooding compound at 65degreeC.

When tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables, the cable shall withstand a minimum compressive load of 220 N/cm (125 lbf/in) applied uniformly over the length of sample. The load shall be applied at the rate of 3 mm to 20 mm per minute and maintained for 10 minutes. The change in attenuation shall not exceed 0.4 dB during loading and 0.2 dB after loading at 1550 nm for single-mode.

When tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test," the cable shall withstand 25 mechanical flexing cycles around a sheave diameter not greater than 20 times the cable diameter. The change in attenuation shall not exceed 0.1 dB at 1550 nm for single-mode fiber.

When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," the cable shall withstand 25 impact cycles. The change in attenuation shall not exceed 0.2 dB at 1550 nm for single-mode fiber.

When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test," using a maximum mandrel and sheave diameter of 560 mm, the cable shall withstand a tensile load of 2700 N (608 lbf). The change in attenuation shall not exceed 0.2 dB during loading and 0.1dB after loading at 1550 nm for single-mode.

When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test," a length of cable no greater than 4 meters will withstand 10 cycles of mechanical twisting. The change in attenuation shall not exceed 0.1 dB at 1550 nm for single-mode fiber.

When tested in accordance with FOTP-37, "Low or High Temperature Bend Test for Fiber Optic Cable", the cable shall withstand four full turns around a mandrel of 10 times the cable diameter after conditioning for four hours at test temperatures of -30degreeC and \pm 60degreeC. Neither the inner or outer surfaces of the jacket shall exhibit visible cracks, splits, tears or other openings. Optical continuity shall be maintained throughout the test.

7. Quality Assurance Provisions

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

All optical fibers > 1000 meters shall be 100% attenuation tested. The attenuation of each fiber at both operational windows shall be provided with each cable reel.

The cable manufacturer shall be ISO 9001 registered.

8. Packaging

Top and bottom ends of the cable shall be available for testing.

Both ends of the cable shall be sealed to prevent the ingress of moisture.

Each reel shall have a weatherproof reel tag attached identifying the reel and cable.

9. Pre-Terminated Drop Cable Assemblies

These assemblies shall be employed when connecting a camera, controller, VMS or other device to the trunk cable and mid-span splice techniques will be used.

Cable used for Drop cable assemblies shall conform to section FOC – 1.5.

10. System configuration - Drop & Insert Applications

Signal from the TOC to local controllers, cameras, and/or variable message signs will be conveyed via the trunk & drop cables in a closed loop configuration. At each controller, the applicable fibers will be routed in & out of the applicable housing using a specified Gator Patch and a mid-span access splice point. Only fibers required for the drop & insert shall be cut, no other fibers in the cable shall be cut without the direction of the engineer.

The length of the drop cable shall be determined after the traffic signal cabinet, pull boxes, and conduit has been installed to insure proper sizing. Twenty feet of drop cable shall be coiled neatly in the pull box with the splice enclosure to provide slack.

11. Fiber Optic Patch Cables (Jumpers)

Any patch cords used for system configuration shall be compatible with fiber types and connectors specified herein. Single-mode patch cords shall be yellow in color and each jacketing material shall conform to the appropriate NEC requirement for the environment in which installed. All cordage shall incorporate a 900um buffered fiber, aramid yarn strength members, and an outer jacket. Patch cords may be simplex or duplex, depending on the application. Single-mode fibers shall be 1.0dB/km @ 1310nm, 0.75dB/km @ 1550.

12. Fiber Optic Connectors

All connectors used in the communication system shall be FC compatible, ceramic ferrule connectors. Factory terminated connectors shall be heat cured epoxy type with a maximum measured loss of ≤ 0.30 dB; No field installable connectors accepted. The operating temperature of all connectors in the system shall be - 40C to ± 70 C with no more than a 0.20dB change across the temperature range.

13. Fiber Optic Closures

Aerial, Pole Mount, Pedestal, and Hand Hole Environments; OSP Closure for Aerial, Pole Mount, Pedestal, and Hand Hole will incorporate the following features:

The closure shall be capable of accepting up to six cables in a butt splice.

The closure shall be capable of storing up to 90" lengths of expressed buffer tubes.

Assembly shall be accomplished without power supplies, torches, drill kits or any special tools. Reentry shall require no additional materials. Sealing shall be accomplished by enclosing the splices in a polypropylene dome that is clamped together with a stainless steel latch and sealed with an O-ring.

Closure shall be capable of strand mounting with the addition of a strand mounting bracket.

Splice case shall be non-filled (no encapsulate), will prevent water intrusion and shall allow re-entry without any special tools. The closure shall be capable of preventing a 10 feet water head from intruding into the splice compartment for a period of 7 days. Testing of the closure is to be accomplished by the placing of the closure into a pressure vessel and filling the vessel with tap water to cover the closure. Apply continuous pressure to the

vessel to maintain a hydrostatic head equivalent to 10 feet on the closure and cable. This process shall be continued for 7 days. Remove the closure, open to check for the presence of water. Any intrusion of water in the compartment containing the splices constitutes a failure. Ensure that the water immersion test has been performed by the manufacturer or an independent testing laboratory, and the appropriate documentation has been submitted to the city.

Buried-OSP Closure for buried applications will incorporate the following features:

Splice case must handle up to four cables. A butt adapter, if applicable could be used to increase capacity to eight cables.

The closure shall be capable of accommodating splice organizers which accept mechanical, single fiber fusion, or multi fiber splices. The closure shall have provisions for storing fiber splices and un-spliced fiber/buffer tubes. The closure shall hold a minimum of 2 splice trays to a maximum of 15 splice trays with each tray housing up to 24 splices. The closure shall be UL rated. Closure re-entry and subsequent reassembly shall not require specialized tools or equipment.

For compression testing, the closure shall not deform more than 10% in its largest cross-sectional dimension when subjected to a uniformly distributed load of 1760 Newtons at -18degreeC and +38degreeC. The test shall be performed after stabilizing at the required temperature for a minimum of two hours. It shall consist of placing an assembled closure between two flat parallel surfaces, with the longest, closure dimension parallel to the surfaces. The weight shall be placed on the upper surface for minimum of 15 minutes. The measurement shall then be taken with the weight in place. Ensure that the compression test has been performed by the manufacturer or an independent testing laboratory, and the appropriate documentation has been submitted to the City.

14. Fiber Optic Termination Hardware

For cross connect applications inside controller cabinets, the fiber optic cable shall be terminated using a 900µm fan-out modular design for the fiber count being terminated. The nonmetallic fan-out shall attach directly to the buffer tube and transition the 250µm coated fibers into the fan-out tubing. The fan-out shall be housed in a Wall Mount Distribution cabinet equipped with the appropriate number of adapters. The fibers shall be connected to the transmission equipment via FC/FC fiber optic patch cables. This hardware scheme shall also be utilized for wall mount applications.

For rack mount applications, the fiber optic cable shall be terminated using a 900µm fan-out modular design for the fiber count being terminated. The non-metallic fan-out shall attach directly to the buffer tube and transition the 250µm coated fibers into the fan-out tubing. The fan outs shall be housed in a Fiber Distribution Center sized for 50% growth based on the initial installation. Appropriate panels for FC adapters shall be included based on the population of the fiber cable installed. If fusion or mechanical pigtail splicing is used for termination points, a splice housing with appropriate 900um pigtails and splice trays shall be used in conjunction with the Fiber Distribution Center.

15. Installation

a. Aerial Installations

All fiber optic components will be installed in accordance with the manufacturer's instructions. All necessary interconnections, services, and adjustments required for a complete and operable data transmission system shall be provided. All pole attachments, service loops, and conduit risers will be placed to minimize the possibility of damage as well as to facilitate future expansion or modernization.

Cable between controllers shall be lashed to a 1/4" EHS messenger with stainless steel lashing wire for aerial installations. The installation will be accomplished in accordance with accepted OSP construction practices. Precautions shall be taken to ensure the installation specifications for the cable are not exceeded (tension, minimum bend radius). The cable shall be marked with an orange weatherproof identifying tag at each pole

location, with print "Caution, Fiber optic Cable".

The cable shall be installed in continuous runs as indicated on the plans. Splices shall be allowed only at drop points and only those fibers necessary to complete the communication path shall be spliced (mid-span access). All other fibers in the cable(s) shall be left undisturbed; with a minimum of 5 feet of buffer tube coiled inside the closure.

Sufficient slack shall be left at each drop point to enable access of the cable components and splicing to occur on the ground (typical 2 x strand height plus 15 ft) (60 feet). For aerial slack storage at splice points, a radius controlling device, commonly referred to as a SNO-SHOE shall be used for securing resulting cable slack at aerial splice points and shall be mounted directly to the strand.

For aerial cable runs exceeding 6 pole spans between splice points (indicated on the plans), two opposing SNO-SHOES shall be placed on the span 50' apart to provide for a 100' service loop for future drops and for slack for repair and pole relocations.

b. Underground Installations

Install fiber-optic cable underground in conduit using cable pulling lubricants approved by the fiber-optic cable manufacturer and the Engineer.

Obtain approval of cable pulling lubricant and method of pulling before installing underground fiber-optic cable.

Use a dynamometer (clutch device) so as not to exceed the maximum allowable pulling tension if the cable is pulled by mechanical means. Do not use a motorized vehicle to generate cable pulling forces.

Keep tension on the cable reel and pulling line at the start of each pull. Do not release tension if the pulling operation is halted. Restart the pulling operation by gradually increasing tension until the cable is in motion.

For pulling cable through manholes, junction boxes, and vaults, feed the cable by manually rotating the reel. Do not pull cable through intermediate junction boxes, handholes, or openings in conduit unless otherwise approved.

For underground installations, the following minimum slack requirements apply; 50 feet at the pull box locations or controller location for midspans, 15' for point to point applications for each cable.

Install communications cable identification markers on each communications cable entering a junction box.

Drop cable shall be routed to the controller cabinets via conduit risers or underground conduit as illustrated in the plans. The cable entrance shall be sealed to prevent water ingress.

The minimum requirement for fiber protection outside a fiber optic enclosure in all cases shall be 3.0mm Fan-out tubing, containing a hollow 900um tube, aramid strength members and an outer jacket, and shall be secured to the cable sheath.

The minimum requirement for fiber protection inside wall mount or rack mount fiber enclosure shall be 900um buffering, intrinsic to the cable in the case of tight buffered fibers, or in the case of 250um coated fibers, a fan-out body & 900um tubing secured to the buffer tube(s).

c. Splicing Methods

All splices shall be accomplished by means of the fusion splice technique and shall not induce more than 0.1 dB attenuation for each splice, and 0.07 dB averages for all splices. Splices found to exceed 0.1 dB attenuation shall be re-spliced, at no additional cost to the Department or City of Franklin, as applicable

until this requirement is met.

Only splice fibers at locations that are identified in the Plans. At these splicing locations, splice all the fibers that are identified on the associated Splice Diagrams in the Plans. Splice Diagrams in the Plans shall not be revised without approval from the Engineer. All splices shall be protected and stored in fiber optic splice closures or aerial splice enclosures.

16. Testing and Documentation

a. OTDR Testing

Prior to the installation, perform on-site on the reel testing. Test all fibers in each reel of cable prior to installation. This testing is for both continuity and attenuation. The tests shall be conducted at 1310nm for single mode fibers. The testing shall be performed using an Optical Time Domain Reflectometer (OTDR) via a "pigtail" splice. The resultant OTDR trace(s) shall reflect overall length and attenuation expressed in db/km. All test results shall be within $\pm 3.0\%$ of factory supplied attenuation measurements for single mode fibers. Testing shall be done in one direction only. Hard copy or disk based (with applicable software) OTDR traces for the testing shall be supplied to the City of Franklin prior to installation of cables. Factory results for installed cable may be accepted at own risk. In either case, on-the-reel test results or factory measurements shall be provided to the City for each cable installed.

Following installation, each section of the installed cable shall be tested for continuity and attenuation as indicated above. The traces shall demonstrate that no change in transmission characteristics has occurred during installation and that any splices meet the requirements herein. This testing can be done in conjunction with the End-to-End testing described below. The traces shall be included in the documentation package provided at the conclusion of the contract.

b. Attenuation Testing

Only completely connected spans will be tested for final End-to-End attenuation (power loss). The testing shall be performed at 1310 nm and 1550 nm for single-mode fibers. The testing shall be conducted using "hand-held" optical test sets and shall be conducted using a two-jumper reference. The testing shall be in one direction only. The results shall be tabulated and be included in the documentation package provided at the conclusion of the contract. Overall loss for each link shall not exceed the cumulative specified losses of the components in the link.

EXAMPLE:

@850nm, a 1 km link with 2 splices and a connector on each end shall not exceed:

5.0dB((3.5dB \pm .25dB \pm .25dB \pm .5dB \pm .5dB))

c. Testing Of Continuous Fiber Optic Cable

The fibers in this installation shall be tested for final End-To-End attenuation (power loss). The overall loss for this link shall not exceed the manufacturer's specifications. The fibers are being installed for future use when demanded and must be operable at this time.

At the conclusion of the contract, 2 copies of system documentation package shall be provided. It shall include at a minimum:

- 1) Post installation OTDR traces for each fiber.
- 2) End-to-End Attenuation measurement for each fiber.
- 3) A splice plan showing the location and configuration of any splices in the system as well as how the transmission scheme is set up.

- 4) Reference manuals for equipment provided.

730.31B ITS Device Control Cabinet**1. Materials**

Material, equipment, and hardware furnished under this section must be pre-approved by the Engineer.

Provide a Type B Model 336A cabinet specifically wired for either CCTV, DMS, WMS or PCS, dependent on the application for the installation.

2. Functional Requirements

The Type B cabinets shall be provided with fully wired back and side panels with all necessary terminal boards, wiring harnesses, connectors and attachment hardware for each cabinet location. All equipment shall be shelf mounted. All terminals and panel facilities shall be placed on the lower portion of the cabinet walls below the shelves.

Submit a cabinet layout for each installation for review by the Engineer. Only cabinets with approved layouts will be accepted by the Department or City of Franklin, as applicable. Each field cabinet shall, as a minimum, be supplied with the following:

- a. Fan and Thermostat
- b. Left Side Power Distribution Panel
- c. Air Filter
- d. Adjustable Shelves (1-4 as required)
- e. Back Panel
- f. Right Side Panel
- g. Locking Mechanism
- h. Lock
- i. Ground Bus (2)
- j. Surge Protection (for Solid State Equipment)
- k. Terminal Blocks
- l. Duplex Power Outlets (GFI protected)
- m. Drawer that opens and slides out for placement of notebook computer
- n. All necessary installation and mounting hardware.

3. CCTV Cabinets

Provide and install all equipment, hardware and software to provide for functional camera installation. The camera installation shall provide an operating camera with equipment ready for future fiber optic communications with the City of Franklin's Transportation Operations Center (TOC).

4. Construction Methods

The cabinet will be secured using 3 steel banding.

One 2-inch conduit nipple will connect the cabinet with the interior of the pole.

Metered power leads, data cables and communications cables shall be run on the interior of the pole.

Handholes shall be provided near the base of poles and near the device location for access to install and maintain the data leads. Strain relief J-hooks will be provided on the interior of the pole at the device location handhole.

Cabinet shall be mounted 48" above finish grade.

730.31C Closed Circuit Television (CCTV) Camera**1. Materials**

Provide a High Definition (HD) IP Power-Over-Ethernet (POE) CCTV PTZ camera, control and communications hardware, enclosure, cabling and mounting apparatus. The CCTV and mounting apparatus shall be an Axis Q6135-LE, Cohu RISE 4228 HD, or equal approved by the City of Franklin.

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 all cabling and all ancillary equipment required to provide a complete and fully operational CCTV system site as shown on the plans.
- d. Verify all wiring meets NEC requirements where applicable.
- e. Cameras shall be mounted in positions which allow 360-degree continuous rotation and mounting arm position shall be approved by the Engineer prior to pole placement.
- f. Furnish and install all appropriate field surge protection devices and ensure proper ground per manufacturer recommendations.
- g. Coordinate with the Department or City of Franklin, as applicable, for IP addresses, and video encoding settings for all CCTV camera sites prior to turn-on/installation and site testing.
- h. The CCTV system shall be compatible with, and integrated into the existing TOC video wall and CCTV control software. Coordinate with the TOC operations personnel for integration of the new CCTV cameras into the existing video wall and video control software systems. Integrate and test all video control and display of the cameras at the TOC.

730.31D CCTV Pole and Lowering Device**1. Materials**

Material, equipment, and hardware furnished under this section must be pre-approved by the Engineer.

In addition, provide a galvanized steel pole standard with a length of 50 feet or as shown in plans. The pole standard shall be designed according to AASHTO Standards and Specifications For Structural Supports For Highway Signs, Luminaires, and Traffic Signals (Current Edition, et al). The pole standards shall be designed for a wind velocity of 90 miles per hour. The steel support shall be finished by the manufacturer in a black gloss color.

Determine the size and design of all steel CCTV support poles and foundations. Shop drawings for the proposed poles shall be submitted to the City of Franklin for review and approval.

Provide a lowering device compatible with the City of Franklin CCTV equipment.

The pole base will provide three 2-inch, non-metallic (High Impact Schedule 80 PVC) conduits into the interior of the pole. One of the conduits will contain the metered power service lines. One conduit will contain the communications cable (Fiber optic or hardwire). The remaining conduit will be a spare with a pull rope installed between the main pull box and the pole foundation.

Metered power leads, data cables and communications cables shall be run on the interior of the pole.

Handholes shall be provided near the base of poles and near the device location for access to install and maintain the data leads. Strain relief J-hooks will be provided on the interior of the pole at the device location handhole.

2. Functional Requirements - Camera Lowering Device Requirements for 50' poles

a. General

The work under this item specifies the additional requirements for the 50' poles which should be equipped with the Camera Lowering Device (CLD). The Camera Lowering Device shall be safely operable by one trained 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. The camera lowering device shall be installed at camera sites as indicated on the plans. Weatherproof connectors (camera to the lowering device) shall allow for adaptation of the camera and the dome type housing for lowering and hoisting. Lifting and lowering shall be done with a motorized gear box (winch). The CLD should be a stand-alone device mounted on a camera pole and included in the cost of the 50' pole. An integrated CLD with pole assembly may be procured provided it meets all specifications.

Design the required pole mounting adapters, brackets and mounting hardware, including extensions and cable entry to the camera mounting pole to accommodate the dome enclosure with pan/tilt unit and pole combination. The pole mounting adapter shall be electrically bonded to the pole. The pan and tilt unit shall be electrically bonded to the mounting adapter. An individual CLD shall be furnished and installed at each CCTV site designed to support and lower a standard closed circuit television camera, lens, housing, PT mechanism, cabling, connectors and other supporting field components without damage or causing degradation of camera operations. This CLD shall consist of an arm mounted suspension contact unit attached to the galvanized steel pole at locations as shown on the Plans. The CLD shall include a tracking guide system permitting the moveable portion of the system to align in the same position every time the system is operated thereby eliminating the need to re-orientate the camera. The electrical / signal connector shall mate without any degradation of performance due to vibration or movement during operation. The cables for the CLD shall not come into contact with any other cables inside the pole.

The entire device, complete with the camera, shall be tested by an independent laboratory experienced in structural, mechanical and electrical testing. It shall be shown to withstand wind forces of greater than 90 mph with a 1.3 gust factor. Certified and dated test reports from the testing facility shall be submitted to the Engineer within 10 days after the testing for review and approval. The top of the pole deflection shall not exceed 1 inch deflection from Center (2-inch deflection diameter) due to 30 mph (non-gust) winds.

All designs, testing results and shop drawings of the camera mounting, lowering device and structural design shall be in compliance with the Contract Documents and Plans and submitted to the Engineer for review and approval 90 days after the Notice to Proceed. Arrange for a factory representative to assist with the assembly and testing of the first CLD onto the pole assembly. Copies of written installation and operating instructions shall be furnished to the Engineer as required by the Contract Documents.

All external components of the CLD shall be made of corrosion resistant materials, anodized, galvanized, or otherwise protected from the environment and dissimilar metals by industry accepted coatings to withstand exposure to a corrosive environment. All pulleys for the camera lowering device and portable lowering tool

shall

have sealed, and self-lubricated bearings. At the discretion of the Engineer, an integrated CLD with pole assembly may be procured.

b. Suspension Unit

Design the required pole mounting adapters, brackets and mounting hardware. The CLD shall have a minimum load capacity 200 pounds with a 10 to 1 safety factor. The enclosure receptacle and camera enclosure shall incorporate a mating device. 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. The latching devices shall lock and unlock by alternately raising and lowering the camera enclosure. When the camera enclosure is latched, all weight shall be removed from the lowering cable. The enclosure receptacle and camera enclosure shall have a heavy-duty tracking guide. The tracking guide and latching devices shall lock the camera enclosure in the same position each time.

Sufficient electrical contacts shall be provided to support all camera functions. The electrical contacts shall be gold coated to prevent corrosion. In addition, replaceable gaskets shall be provided to seal from moisture and dust the electrical contacts and latching devices.

The CLD shall be designed to preclude the lifting cable from contacting the CCTV cabling. 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.

The CLD shall support the Camera Assembly a minimum of 20" from the pole. The CLD shall be designed to permit a ± 3 degree of horizontal adjustment for leveling the dome enclosure. The lowering cable shall be a minimum 5/32" diameter stainless steel aircraft cable with a minimum breaking strength of 2400 pounds.

Weights and/or counterweights shall be provided as necessary to assure that the alignment pin and connectors are proper for the camera support to be raised into position without binding and that sufficient weight is present on the camera and its control components that it can be lowered properly.

c. Portable Camera Lowering Device Tool

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 CLD and the Steel Camera Pole and meets the following requirements:

- 1) The Portable Lowering Tool shall be one recommended by the manufacturer of the CLD
- 2) The Portable Lowering Tool shall have a minimum load capacity of 200 pounds with a 10 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.
- 4) This tool shall be compatible with the hand hole of the pole and the CLD 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.

- 8) The Portable Lowering Tool shall be provided with an adapter for operating the lowering device by a portable drill using a clutch mechanism.
- 9) The Portable Lowering Tool shall be equipped with a positive locking mechanism to secure the cable reel during raising and lowering operations.

d. Construction Methods

Install the CCTV pole standard per the TDOT Standard Specifications, and pole manufacturer's design standards.

The CCTV camera shall be installed per the manufacturer Installation and Operation Manual, in the outdoor pendant configuration.

The CCTV control and communications hardware and enclosure shall be wired and installed per the City of Franklin Standard Detail manufacturer Installation and Operations Manuals indicated above.

TRAFFIC SIGNAL SUPPORTS

730.32 Cantilever Signal Supports

This Subsection applies 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 shown on the Plans. The Plans indicate bracket/mast arm lengths.

Furnish poles consisting of a straight or uniformly tapered shaft, cylindrical or octagonal 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 A27, Grade 65-35. Gray iron castings shall conform to ASTM A126, Class A.

All mast arms shall be compatible with the poles in material, strength, shape, and size.

Determine the size and design of all steel signal support poles and foundations. Shop drawings for the proposed poles, support structures and foundations shall be submitted to the Department and the City of Franklin for review and approval.

A. Anchor Base

Secure an anchor base of one-piece cast steel or steel plate of adequate strength, shape, and size to the lower end of the shaft. Place the base so as to telescope the shaft, and weld at the top and bottom faces with continuous fillet welds so that the welded connection develops the full strength of the adjacent shaft section to resist bending action. Provide each base with a minimum of four holes to receive the anchor bolts. Provide cast steel bases with removable cast iron covers for anchor bolts and tapped holes for attaching covers with hex head cap screws.

Provide a welded frame handhole, 5 x 8 inches minimum and located with a clear distance above the base of no less than the pole diameter, "D". Weld a 1/2-inch 13 UNC grounding nut to the inside of the pole at a point readily accessible for wiring.

B. Shaft

Fabricate shafts from the best, hot-rolled basic open hearth steel. The shaft 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 feet. The shaft shall be longitudinally cold-rolled to flatten the weld and increase the physical characteristics so that the metal will have minimum yield strength of 48,000 pounds per square inch. Where transverse full penetration circumferential welds are used, the shaft fabricator shall furnish to the Engineer certification that: (1) all such welds have been radiographed and ultrasonically tested by an independent testing laboratory using a qualified Nondestructive Testing (NDT) technician and (2) the NDT equipment has been calibrated annually.

Fit the shaft 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.

C. Mast Arms

Provide mast arms fabricated and certified in the same manner as the upright shafts and that have the same physical characteristics.

The mast arms shall meet the design requirements necessary to support rigidly mounted traffic signals as shown on the Plans. All arms shall include a removable cap at the tip, grommeted 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.

Connect mast arms to the upright pole at a height necessary to provide a minimum clearance of 16 feet 6 inches and a maximum clearance of 19 feet under the traffic signal heads. Install separate signal heads to provide the same clearance.

D. Finish

Galvanize steel poles, mast arms, and hardware in accordance with ASTM A123.

Galvanize all steel and cast iron components, hardware, and threaded fasteners, except anchor bolts, after fabrication in accordance with ASTM A123, or A153 or A385, as applicable.

The steel supports shall be finished by the manufacturer in Franklin Green (Downtown Historical District) or Black, as specified by the plans. Any deficiencies in the finish shall be touched upon a method approved by the manufacturer and the City of Franklin.

730.33 Steel Strain Poles

Provide steel strain poles consisting of a uniformly tapered or equivalent upright shaft fitted with a removable pole top, J-hook wire support and 45-degree wire inlet near the top, a span wire clamp, a 5 x 8 inch handhole with reinforced frame and cover, bent anchor bolts, and all other accessories needed 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 shown on the Plans, suspended from a span wire assembly. Fabricate and certify the poles as specified for the upright shafts in **730.32**.

Determine the size and design of all steel strain poles and foundations. Shop drawings for the proposed poles shall be submitted to the Department and the City of Franklin for review and approval.

Determine the shaft length required to meet field conditions and vertical clearances of signal heads over the roadway. The signal head clearance shall be a minimum of 16 feet 6 inches and a maximum of 19 feet. Fasten the span wire no closer than 1 foot 6 inches from the top of the pole.

Unless otherwise specified, provide all strain pole traffic signal supports with a one-piece anchor type base, fabricated from drop forged or cast steel of sufficient cross-section to fully develop the ultimate strength of the poles. Fasten the base to the pole with a welded connection that develops the full strength of the pole. Provide the base 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. Provide removable cast iron covers for the anchor bolts.

The shaft shall be fabricated from material providing minimum yield strength of 48,000 pounds per square inch after fabrication.

Galvanize the steel poles and hardware in accordance with ASTM A123.

Galvanize all steel and cast iron components, hardware, and threaded fasteners, except anchor bolts, after fabrication in accordance with ASTM A123, or A153 or A385, as applicable.

730.34 Pedestal Support Signal Poles

Provide pedestal poles consisting of one upright pole with suitable base and other accessories or hardware as required making 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 4-1/2 inch outside diameter.

The steel supports shall be finished by the manufacturer in Franklin Green (Downtown Historical District) or Black, as specified by the plans. Any deficiencies in the finish shall be touched up in a method approved by the manufacturer and the City of Franklin.

A. 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. Provide a handhole in each base.

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

Furnish bases with four steel anchor bolts of sufficient size and length to securely anchor the base to the concrete footing. Weld the shaft 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 T-6 temper after fabrication, and meeting ASTM B221.

Type A anchor base shall be made of sand-cast aluminum alloy 356-T6 meeting ASTM B26 - SF 70A-T5 specifications.

B. Type "B" Pedestal (Steel)

Pedestals shall be fabricated from a 4-1/2 inch (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 inches. The top opening of the base shall be threaded to receive the shaft. Provide a handhole in each base.

Furnish bases with four steel anchor bolts of sufficient length to securely anchor the base to the concrete footing.

730.35 Wooden Pole Signal Supports**A. General**

Provide wooden poles of the class and length shown on the Plans and that meet **917.11**. Set poles to the depth shown on the Plans, and fit them with all the necessary hardware to make the installation complete.

The signal head clearance shall be 16 feet 6 inches minimum and 19 feet maximum. Fasten the span wire at least 2 feet below the top of the pole.

B. Guying Components

Guy clamps shall be steel, 3-bolt type, 6 inches in 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 the Engineer's approval.

Attach guy wire to the pole with a 5/8-inch diameter x 12-inch length single strand angle-type eye bolt with 2 x 2 inch square cut washers; lock washer, and square nut.

Instead of the eye bolt specified above, an angle single strand eye of drop forged steel may be used, fastened on threaded end of span wire eye bolt.

Sidewalk guy fittings shall consist of 2-inch inside diameter standard galvanized steel pipe of required length with malleable iron pole plate and guy clamp. Fasten the pole plate to the pole with a 3/8-inch thru bolt and 1/2-inch lag screws.

All guying components and hardware shall be galvanized in accordance with ASTM A123 or A153.

Anchors for guys shall be of the pressed steel four-way expanding fluke type or of the steel or malleable iron sliding plate type. The minimum unexpanded diameter shall be 8 inches, and the minimum expanded area shall be 110 square feet. Coat anchors with a black asphaltic paint.

Guy anchor rods shall be drop-forged steel, 3/4-inch diameter and 7-foot minimum length, threaded, of the single thimble eye type, with a square anchor bolt nut.

730.36 Pole Location

Install all signal support poles at the locations shown on the Plans or where directed by the Engineer. Some field adjustments may be required in order to avoid conflicts with either underground, above ground or overhead utilities. Determine and stake the optimum locations for the poles/controller and for receiving approval from the City of Franklin before installation begins. Proper roadside clear zones shall be followed.

COMPENSATION**730.37 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, installed, or both furnished and 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-inch lenses per assembly (including arrow lenses).
3. The third digit is the quantity of 8-inch lenses per assembly.
4. The letter "A" indicates an arrow lens and the digit following the "A" indicates the number of 12-inch 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 the following:

1 = one face

5 = five 12-inch lenses

0 = zero 8-inch lenses

A2 = two 12-inch arrow lenses

H = Arrow lenses placed horizontally with respect to circular indications

A. Removal of Signal Equipment

The Department will measure items of equipment or material designated or required for removal on a per each intersection basis. Removal and salvage of all signal heads, poles, control equipment, cabinets, span wire, cable, and similar features to be performed at an intersection shall be included as a unit cost per each intersection. This includes the cost of stockpiling salvable equipment and delivery to the City of Franklin, as noted in the Plans. Remove any traffic control related equipment that is in conflict with the proposed equipment and deliver to the City of Franklin Street Department facility. All new or temporary signals shall be removed and stockpiled in such a manner that the removed equipment will not be damaged. Poles shall be removed complete and undamaged. The pole shall be cleaned of any concrete foundation material. Any damage due to negligence or lack of proper care of equipment shall be replaced in kind. The replacement of the equipment shall be at no additional cost to the Department or City of Franklin. All such removed and salvageable equipment is now and shall remain the property of the City of Franklin.

Signal Head Assembly (includes Pedestrian Signal Heads)

The Department will measure signal heads of the type shown on the Plans 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

The Department will measure each pull box of the type required 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

The Department will measure Electrical Service Connections 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.

Signal Cable

The Department will measure the length of Signal Cable of each size (number of conductors) installed in linear feet to the nearest foot from point to point along the routing for each cable.

The Department will make horizontal measurements 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 mastarms, the Department will measure from center of vertical support to signal head where cable terminates.

The Department will make vertical measurement 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.

The Department will make no additional allowance for slack length, length inside equipment or supports (except as noted), length for the required 360-degree drip loop, and similar instances requiring additional length of cable.

Span Wire

The Department will measure Span Wire Assembly, Tether Wire Assembly, and Messenger Cable by type in linear feet to the nearest foot. 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. The Department will make no additional allowance for slack length and other instances requiring additional length of wire.

Steel Conduit Riser Assembly

The Department will measure conduit riser assemblies per each for each size conduit riser installed on the outside of a pole, as shown on the Plans. This item includes conduit, weatherhead, conduit, fittings, nuts, washers, banding, clamps, grounding, and other items necessary for installation.

Conduit

The Department will measure conduit in linear feet to the nearest foot for each size and type of conduit installed.

The Department will measure underground conduit 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, or
4. From center to center of pole foundations or pole foundation and controller foundation.

The Department will add:

1. 1 foot to the above measurements for each entry to a pull box or pole foundation and each exit of a pull box or pole foundation.
2. 3 feet to the measurement for each capped extra entry (conduit stub) or exit to a pull box or pole foundation installed, as shown on the Plans.
3. 3 feet to the measurement for each connection between underground conduit and above ground riser.
4. 3 feet to the measurement for each entry or exit to a foundation for a base-mounted controller.

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

Vehicle Detector (Description)

The Department will measure vehicle detector loop amplifier per each unit, including the cable and associated hardware necessary to electrically connect the amplifier to the controller and loop lead in.

The Department will measure two and four channel card rack type amplifiers per each unit, including the cable, card rack(s), and associated hardware necessary to electrically connect the amplifiers to the controller and loop lead-ins.

The Department will measure radar detectors per each including all mounts/supports, cable boxes, conductors, detector rack cards, interface devices and all items necessary for a fully functioning Wavetronix detection system.

The Department will measure Radio/GPS activated priority control detectors with all antennas, radio units, phase selectors, cable, interface devices and all items necessary for a fully functioning Radio/GPS activated priority control system.

The Department will measure wireless magnetometer detectors per each including all in-pavement installations, repeaters, mounts/supports, isolators, access point controller cards, radio wired interface devices and all items necessary for a fully functioning wireless detection system.

Shielded Detector Cable

The Department will measure the two-conductor shielded detector cable installed between the controller cabinet and the loop detector wires in linear feet to the nearest foot.

The Department will make horizontal measurements (overhead and underground) 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, or
4. From center to center of pull box or pole and controller foundation.

The Department will make vertical measurements 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, or
3. From ground level to the bottom of controller.

The Department will make no additional allowance for slack length, length inside equipment or supports (except as noted), splices, and similar instances requiring additional length of cable.

Saw Slot

The Department will measure the length of saw slot for installation of detection loop and lead wiring in linear feet to the nearest foot. Measurement for detection loops in the traffic lanes will be made based on the loop size shown on the Plans (the nominal length plus the nominal width) times 2. The Department will make no additional allowance for saw overruns to obtain full depth of saw slot or diagonal cuts to prevent sharp bends in the loop wire. The Department will measure saw slot for detection loop leads 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.

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

Loop Wire

The Department will measure the length of loop wire for installation of detection loops and lead-ins in linear feet to the nearest foot. Measurement will 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. The Department will make no additional allowance for slack length, length inside equipment or supports, splices, and similar instances requiring additional length of wire.

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

Controller

The Department will measure controllers as one complete unit, installed, per each. This item includes all auxiliary equipment shown the Plans to provide signalization control as shown on the Plans, and all hardware, including the cabinet (and cabinet foundation, if base-mounted), necessary for installation.

Wood Pole

The Department will measure Wood Poles, of the type and size shown on the Plans, per each, installed.

Guying Device

The Department will measure Guying Devices, of the type shown on the Plans, per each, installed. This item includes the guy wire, anchor, clamps, and all other components shown on the Plans necessary for installation.

Steel Strain Pole

The Department will measure Steel Strain Poles of the type and size shown on the Plans, per each, installed. This item includes the pole, foundation, anchor bolts, grounding, and all other hardware shown on the Plans necessary for a complete installation.

Cantilever Signal Support

The Department will measure Cantilever Signal Supports, of the type and size shown on the Plans, per each, installed. This item includes the vertical pole shaft, mast arm, foundation, anchor bolts, grounding, and all other hardware shown on the Plans necessary for a complete installation.

Service Cable

The Department will measure two conductor power service cables, of the type and size shown on the Plans, in linear feet to the nearest foot, 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. The Department will make no additional allowance for slack length or other instances requiring additional length of cable.

Pedestrian Pushbutton with Sign

The Department will measure Pedestrian Pushbutton with Sign 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

The Department will measure Pedestrian Signal Display with Pushbutton and Sign 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.

Portable Traffic Signal

The Department will measure Portable Traffic Signal, of the type shown on the Plans or as directed by the Engineer, per each, installed. This item includes the all of the software and hardware necessary for a complete installation.

Pedestal Support Signal Pole

The Department will measure Pedestal Support Signal Poles, of the type and size shown on the Plans, per each, installed. This item includes the vertical pole shaft, base, foundation, anchor bolts, grounding, and all other hardware shown on the Plans necessary for a complete installation.

Internally Illuminated Street Name Signs

The Department will measure Internally Illuminated Street Name Signs of the type and size shown on the Plans, per each, installed. This item shall include the street name sign, terminals, lamps, attachment hardware, electrical connection, and testing for a complete installation.

Fiber Optic Drop Cable

The Department will measure Fiber Optic Drop Cable, of the type and size shown on the Plans, in linear feet to the nearest foot, installed. Horizontal runs will be measured center to center of poles. Vertical runs will be measured from the ground to the weather head 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 weather head. This item includes all necessary attachment hardware.

Interconnect Cable – Fiber Optic

The Department will measure Interconnect Cable - Fiber Optic, of the type and size shown on the Plans, in linear feet to the nearest foot, installed. Horizontal runs will be measured center to center of poles. Vertical runs will be measured from the ground to the weather head 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 weather head. This item includes all necessary attachment hardware.

Fiber Optic-Splice Closure & Aerial Splice Closure

The Department will measure the Fiber Optic Splice Closure, as shown on the Plans, per each installed. This item includes all materials, labor, tools, equipment, and incidentals necessary to complete the work, and all testing and documentation.

Fiber Optic Termination Panel

The Department will measure Fiber Optic Termination Panel, of the type and size shown on the Plans, per each installed. Termination panels shall contain the necessary fiber optic connector modules, label covers and associated splicing for locations indicated on the Plans. This item includes all materials, labor, tools, equipment, and incidentals necessary to complete the work, and all testing and documentation.

Fiber Optic Fusion Splice

The Department will measure Fiber Optic Fusion Splice, as shown on the Plans, per each splice location installed. The item shall include but not limited to, all fusion splices at that given location, all ancillary and incidental materials, testing, documentation, and all labor and equipment necessary to complete the work for all necessary splices at a given location. This price shall be full compensation for all labor, tools, materials, equipment, and incidentals necessary to complete the work.

Fiber Optic Fusion Splice

The Department will measure Fiber Optic Storage Bracket (Aerial), of the type and size shown on the plans, per each installed. This item shall include all materials, labor, tools, equipment, and incidentals necessary to complete the work, and all testing and documentation.

CCTV Camera System

The Department will measure CCTV Camera System, as shown on the Plans, per each installed and fully operational. This item 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 (if required and approved), outdoor rated category 5e 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, as well as the satisfactory completion of all testing requirements and all work, equipment and appurtenances as required for a full CCTV Camera System.

This item shall also include all local configuration and control manufacturer software, 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; integration and configuration into the existing TOC video wall and controller, and testing for display of the video on the existing video wall.

CCTV Pole and Lowering Device

The Department will measure CCTV Pole and Lowering Device, of the type and size shown on the Plans, per each, installed. This item includes the pole, foundation, anchor bolts, grounding, lowering device, portable lowering device tool, and all other hardware necessary for a complete installation.

730.38 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

<i>Item</i>	<i>Pay Unit</i>
Traffic Signal	Lump Sum
Removal of Signal Equipment	Each
Signal Head Assembly (Description)	Each

Install Pull Box (Description)	Each
Electrical Service Connection	Each
Signal Cable – (Description)	Linear Feet
Span Wire Assembly (___ pounds min. break strength)	Linear Feet
Tether Wire Assembly – ___" Diameter	Linear Feet
Messenger Cable – ___" Diameter	Linear Feet
Riser Assembly (Description)	Each
Conduit ___" Diameter (Type)	Linear Feet
Vehicle Detector (Description)	Each
Shielded Detector Cable	Linear Feet
Saw Slot	Linear Feet
Loop Wire	Linear Feet
Controller (Description)	Each
Wood Pole (Description)	Each
Guying Device (Description)	Each
Steel Strain Pole (Description)	Each
Cantilever Signal Support (Description)	Each
Pedestal Support Signal Pole (Description)	Each
Service Cable	Linear Feet
Pedestrian Pushbutton with Sign	Each
Pedestrian Signal Display with Pushbutton and Sign	Each
Portable Traffic Signal (Type)	Each
Internally Illuminated Street Name Signs	Each
Fiber Optic Drop Cable (Description)	Linear Feet
Interconnect Cable - Fiber Optic (Description)	Linear Feet
Fiber Optic Splice Closure	Each
Fiber Optic Aerial Splice Closure	Each
Fiber Optic Termination Panel (Description)	Each
Fiber Optic Fusion splice	Each
Fiber Optic Storage Bracket (Description)	Each
CCTV Camera System	Each
CCTV Pole (Description with lowering device)	Each

The unit price to be paid includes the cost of furnishing and installing, complete in place, each of the various types of equipment required by the Summary of Quantities shown on the Plans. Total payment is full compensation 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 specified herein, including restoration of pavements, sidewalks, and appurtenances damaged or destroyed during construction and tests. All additional materials and labor not specifically shown or called for, which are necessary to complete the traffic signal installation or traffic signal system described, will be considered incidental to the system and no additional allowance will be made.