ITEM 632 TRAFFIC SIGNAL EQUIPMENT

632.01 Description. This work consists of furnishing and installing traffic signal equipment, complete and ready for service. This work also includes necessary excavation and backfill, disposal of discarded materials, restoration of disturbed facilities, and surfaces to a condition equal to that existing before the Work started, and electrical testing as specified.

Pull boxes, conduits, ground rods, and cable splicing kits required for traffic signal equipment installations are specified in Item 625.

632.02 Contractor Personnel Requirements. Assign a full time employee of the Contractor to act as the project supervisor. Do not change the project supervisor without giving the Engineer written notice. Provide International Municipal Signal Association (IMSA) certified documentation for Contractor employees if requested by the City.

An IMSA level two certified technician shall perform all of the following controller work:

1. Back panel wiring terminations
2. Programming
3. Testing or turn on
4. Troubleshooting

Assign a foreman to each crew performing work for the project. A foreman shall be present at all times when work is performed by the crew. Each foreman shall be an IMSA level one certified technician. Provide prior verbal notice to the Engineer in order to replace a crew foreman.

In addition, any trade person performing the following work shall be an IMSA level one certified technician:

1. Cable splices
2. Signal head installation
3. Cable and wire installation
4. Power service installation
5. Ground rod testing
6. Cable insulation testing
7. Field wiring terminations

632.03 Materials and Equipment. Furnish new materials and equipment of first quality, of current design, and free from defects.

Use electrical parts, wire, switches, and other elements of the installations capable of carrying the required current without excessive heating or drop of potential.

Ensure that major items or assemblies of equipment bear a nameplate, indelible marking, or brand that identifies the type, model, catalog number, and manufacturer.

Furnish materials and equipment conforming to:

Concrete, Class C 499, 511
Steel*:
Poles, supports, arms, appurtenances and anchor bases 730.02, 730.03, 730.04, 730.05, 730.06, 730.07, 732.12, 732.11
Pedestals 732.15
Backplates 732.22
Hardware 730.08
Stainless steel hardware 730.10
Other Items:
Conduit, rigid 725.04, 725.051, 725.052
Ground rod 725.16
Pull boxes 725.06, 725.07, 725.08, 725.12
Identifying tags or bands 725.02
Signal heads 732.01, 732.02, 732.03, 732.05
Lamps 732.04
Pushbuttons 732.06
Detectors 732.08

Wood poles..... 732.13
Down guys..... 732.14
Conduit risers 732.16
Cable supports 732.17
Messenger wire..... 732.18
Cable and wire..... 732.19
Backplates 732.22
Tether Wire 732.185

* Acceptance of materials and products is based on certified test data, furnished in triplicate, or on test results of samples according 106.04, as required by the Laboratory.

632.04 Certified Drawings. Furnish certified drawings according to 625.06. Additionally submit all required materials for approval to the City of Columbus, Division of Design and Construction, Construction Section, 1800 East Seventeenth Avenue, Columbus, Ohio 43219. Include in the material submissions one (1) complete set of catalog cuts, diagrams, shop drawings, brochures or other descriptive material for the signal items that the Contractor intends to furnish that have not been specifically named in the plans by product model number. Provide a detailed list of all variances from the ODOT specifications and from the specifications contained in the plans for each non-specified item that does not comply 100% with these specifications. Unless otherwise stated by the Contractor, the City will consider the supplied items as being in strict accordance with all specifications.

632.05 General. Ensure that major items of traffic signal equipment used in combination are compatible, interchangeable, and, whenever feasible, provided by the same manufacturer or supplier. Furnish electrical materials, equipment, and installations according to the National Electrical Code and the National Electrical Safety Code, and conform to local laws and codes.

Ensure that the traffic control equipment installed in controller cabinets are shop prewired according to a wiring diagram that conforms to plan and specification requirements of the specific project and intersection, and show all wire harness and field connections required, with abbreviations according to Table 632.05-1. Furnish four (4) sets of a neat and legibly drawn wiring diagram, reproduced on durable paper with each controller cabinet. Place one copy in a plastic envelope mounted horizontally and securely fastened to the inside of the main controller cabinet door. Position the envelope so that its opening is to the right or left and so that it does not block any part of the air filter or the air intake vents located in the door.

Provide the wiring diagrams and service and instructional manuals with the controller cabinet. Clearly note any deviations, changes, additions or other modifications on the diagrams and manuals to reflect the exact equipment provided.

Identify cable and wire by tags or bands at pull boxes and controller cabinets, with size, material, and method of marking conforming to 725.02, except ensure that the identification on the tags or bands conforms to the wiring diagram with abbreviations according to Table 632.05-1. The Contractor may identify field wiring using an indelible pen on a plastic tag instead of embossed letters.

Use spade terminals for wiring connected at signal heads and the wiring connected at terminal blocks within controller cabinets. However, for incoming power wiring, use

either spade terminals or bared conductor wire connected to terminal points utilizing screw or spring applied clamping surfaces compatible with both cooper and aluminum wire and providing a positive grip. Neatly lash and fasten completed wiring to interiors with clamps and/or ties.

TABLE 632.05-1 CABLE AND WIRE IDENTIFICATION

Cable	Tag
Ground	GND
Power (2 wire)1∅ 120 volt	AC +AC- or ACN
Phase A Phase 1 Phase 1 northbound left turn lanes	∅ A ∅ 1 ∅ 1 NBLT
Phase A, pedestrian signal	∅ A PD
Overlap, phase A + C Overlap, phase 1 + 6	∅ A + C ∅ 1 + 6
Detector lead-in, phase A Detector lead-in, phase 1 Detector lead-in, phase 1 northbound left turn lanes	DET A DET 1 DET 1 NBLT
Detector lead-in, phase A (call type) Detector lead-in, phase 1 (call type) northbound thru lanes	DET A CALL DET 1 CALL NB-THRU
Detector harness[1]	DET A
Interconnect	IC
Pre-emption, fire	PE FIRE
Pre-emption, railroad	PE RR
[1] Place the tag next to the MS plug at the detector amplifier.	

When constructing the traffic control system, cooperate with the agency supplying the electric service. Supply 120volt, single-phase, two-wire (grounded neutral), 30-amp power to the controller cabinet.

After completion of the 10-day performance test in compliance with 632.28 and until acceptance, the Contractor is responsible for the care and maintenance of traffic control equipment installed or reused as part of the Contract.

Upon acceptance of the project, transfer to the City of Columbus all manufacturers' guarantees or warranties covering installed electrical or mechanical equipment. Furnish four (4) sets of cabinet wiring diagrams per controller cabinet and two (2) sets of service manuals and instructional manuals on installation and maintenance for each different type, model, or system of equipment used on the project.

Include in the service and instructional manuals sections covering the general description of equipment, equipment installation procedures, equipment programming procedures, theory of operation with system description, including block diagrams and detailed circuit diagrams, preventive maintenance, field trouble analysis, bench trouble analysis, troubleshooting analysis chart, wave forms, voltage measurements, voltage measurement charts, parts list, electrical interconnection drawings, schematic and logic

diagrams, assembly drawings with pictorial diagrams showing physical locations and identification of each component.

632.051 Acceptance of Signal. The Division of Design and Construction will be the sole agency to accept any traffic signal installation on behalf of the City. The Division will not give permission to the Contractor to either place a proposed signal on flash or activate it or accept any signal installation if any electrical clearance regulations or any OSHA electrical safety clearance are in violation. If any proposed aerial cable is attached to any non-Department of Public Service owned pole, then permission to attach must be granted by the pole owner and attachment confirmation received by the Division of Design and Construction before the signal will be accepted. If a recorded easement is required, deliver a copy of the recorded easement to the Division's Project Engineer before the signal installation is accepted.

632.052 Project Signal Inspection, Signal Plan Changes & Notification. In addition to project personnel, the Division of Design and Construction, Construction Section, Traffic Signal Construction Coordinator will be present to inspect the signal installation at all signals within the jurisdiction of the City of Columbus. Obtain approval for all changes to the signal plans from the Division of Design and Construction, Design Section, prior to their implementation. Contact project personnel to arrange a time and date for a traffic signal preconstruction conference. Do not start signal work prior to this meeting.

632.054 Installation Layout. Engage a Professional Surveyor to locate and mark all stationed signal items using the station numbers and offsets provided in the plans. The Surveyor shall also set controls for mastarm structures when present so the mastarm alignment can be set properly. The Surveyor shall set proper pole, pedestal and cabinet foundation elevations and stake all associated radii so foundations can be aligned properly. Obtain approval from the Division of Design and Construction, Construction Section, Traffic Signal Construction Coordinator for all foundation locations and elevations prior to installing them. The Surveyor shall also stake the right-of-way anytime a stationed traffic signal item is within one (1) foot of the right-of-way. When requested by Engineer, the Surveyor shall set and mark a proposed top-of-curb elevation stake at the back-of-curb or if no curb an edge-of-pavement elevation stake at the proposed edge-of-pavement. Radially align this elevation stake with the radius hub and signal/support pole location stake. Costs incurred for this service shall be incidental to the cost of the project or provided under a construction layout stake item.

632.055 Contractor Access to Existing Controller Cabinet. A representative from the Division of Planning and Operations, Operations Section, will be present anytime the Contractor requires entry into an existing control cabinet to perform any cabinet field wiring change or field wiring hookup. Contact the Division of Design and Construction, Construction Section, Traffic Signal Construction Coordinator to make arrangements. Provide a three (3) City workday notice. The representative will act in a supervisory and/or informational capacity only unless otherwise stated in the plans. Existing cabinet wiring that was previously disconnected by Division of Planning and Operations will be connected by the Division if connection is required for proper operation of the traffic signal. The Division's representative will oversee the Contractor's connection of all Contractor-installed cable. There is no charge for this representative between the hours of 8am and 3pm, Monday through Friday, excluding City holidays. Outside of these

hours, the Contractor shall be charged an hourly rate to cover personnel and equipment costs. A four-hour minimum charge shall apply.

632.056 New Signal Flash Operation. Place the signal on "flash" no sooner than eight (8) days prior to the site generating the volumes required to meet signal warrants at this location. Do not place the signal on flash until the Division of Design and Construction has checked the signal installation and has given the Contractor approval to flash the signal. If any OSHA electrical clearances are found to be in violation, correct all violations before placing the signal on flash. Do not place any signal within an active interconnected system on flash until the system has established reliable communication with the controller. Also, do not place the signal on flash until all ADA ramp/pathways, permanent pavement markings and lane control signs have been properly installed. The Contractor may use temporary pavement markings in lieu of permanent pavement markings if they reflect the permanent pavement marking layout. Have the stop lines in place prior to the signal being placed on regular operation. During the flash period, install the "SIGNAL AHEAD" (W47-36) and "NEW SIGNAL" (CW-318-24) signs but keep them covered until the signal is placed on regular operation. The signal shall flash for seven (7) days prior to being placed on regular operation. If the signal flash sequence is different from the “as per plan” flash sequence, make changes as needed to obtain the proper flash sequence for each time period. During the signal flash period, the mainline signals shall flash yellow.

632.06 Vehicular Signal Head, Conventional. Furnish heads in arrangements such that from one to a maximum of five sections assembled with the specified lens size, color, and circular or arrow configuration form a specific signal face. Mount signal faces alone as a one-way head, or combined with additional faces to form a two-way, three-way, or a maximum of a four-way head.

Furnish multi-way heads with top and bottom brackets for mounting purposes. Fit faces of lesser height in multi-way heads with pipe spacers. Close openings unused for mounting purposes with weatherproof caps.

Install signals in a plumb condition, using a balance adjuster only if necessary. Fit heads mounted on mast arms, except those intended to be rigidly mounted, with a universal hanger allowing the head to swing in both longitudinal and transverse directions. Use disconnect hangers for suspended heads when specified.

Orient each signal face to its traffic approach, and lock faces in place by the serrated or other type device incorporated in signal housing and support hardware.

Install LED lamps in each section.

When specified, furnish backplates.

632.07 Vehicular Signal Head, Optically Programmed. Furnish heads of this type consisting totally of optically programmed sections unless an intermix of optically programmed and conventional sections is specified. Install lamps in each optically programmed section.

Program each signal section according to the plan requirements. For 8-inch sections, use an extender tool as recommended by the manufacturer to program each section. Upon completion of the project, deliver one extender tool per project to the City.

When specified, furnish backplates.

632.08 Pedestrian Signal Head. Mount pedestrian signal heads on the side, not on the top, of a pole or pedestal unless specified otherwise in the plans. Mount the pedestrian signal head on a two-hinged type bracket that is bolted or banded (2 bands per bracket) to the pole, except brackets used on mastarm poles shall be bolted only. Field drill and reinforce the pedestrian head using manufacturer-supplied reinforcement so it fits on the hinged bracket. When two pedestrian signal heads are attached to a single pole, mount the bottom of the mainline signal head at 8 foot above foundation level and mount the second (side street) signal head one-half its housing height above the first. Aim the pedestrian unit at the centerline of the crosswalk area that is opposite of the unit. Also give the pedestrian unit a slight downward angle. Close openings unused for mounting purposes with weatherproof caps.

632.09 Pedestrian Pushbutton. Properly orient and install pushbuttons on poles or pedestals. Service pushbuttons mounted on steel poles by wiring inside the poles. Furnish 3/4-inch diameter holes through the back of the housing and the pole wall, install a rubber grommet, and route wiring through until no external wiring is visible. Plug any unused conduit attachment holes. Attach the housing by machine or self-tapping screws in the housing back wall. Service pushbutton mounted on wooden poles through conduit. Mount the center of the pushbutton 42 inches above the pedestrian pathway surface. Apply a bead of clear silicon sealant to the top of the pushbutton housing (1 inch each side of top center) against the pole to prevent water from entering the back of the pushbutton housing. Furnish two aluminum pedestrian pushbutton signs of the legend and size required with each pushbutton. Mount the bottom of the signs just above the top of the pushbutton.

632.10 Loop Detector Unit. Install and tune detector units to their loops with the sensitivity set for optimum operation and any interference or cross talk eliminated between other detector units in the cabinet. Perform a field check to ensure that no extraneous detections are occurring by observing each detector unit's operation to determine that a signal occurs only when a vehicle enters its associated loop. If actuations are observed when there is no vehicle in the loop, eliminate the extraneous detections.

632.11 Detector Loop. Saw slots in the pavement for installation of vehicle detector loop wire in the configuration, dimensions, and combinations required. Cut an extension from the loop to the pavement edge to allow wire routing to an adjacent pull box.

Furnish slots 1/16 to 1/8-inch wider than the outside diameter of the loop wire or tubing. The loop slot depth shall be 4 inches. If an existing paved shoulder is 4.5 inches thick or more, the Contractor may install the loop wire in a saw slot cut across the shoulder. When paved shoulders are less than 4.5 inches thick, install the loop wire and its conduit raceway as per ODOT Standard Drawing TC-82.10. Use a single 3/4-inch or 1-inch steel conduit raceway for each loop. Ensure that the slot depth provides a covering of not less than 3/4-inch above the uppermost detector wire tubing after the loop installation is completed. Before installing loop detector wire, brush and blow all slots clean of loose material and completely dry. Install loop detector wire according to 632.23.

Fill the slots completely with a flexible embedding sealant, prequalified according to the City's Qualified Products List (QPL). Do not disturb slots until sealant has cured.

Cured sealant shall be level with or higher than the pavement surface. Take care in placing loop sealant to ensure that all sealant is placed in the saw slot.

632.14 Foundations. Locate support foundations, and stake with the proper elevation. If underground or overhead obstacles are encountered during stakeout, or to correct slope and subsurface difficulties, change foundation location and orientation with the approval of the Engineer. Ensure that the approved location provides a safe clearance from overhead power lines for construction operations, in compliance with the National Electrical Safety Code. The Contractor is responsible for the correct location, elevation, and orientation for all poles and pedestals installed on the foundations.

Orient one side of the anchor base pole foundation cap parallel to the sidewalk, back-of-curb or edge-of-pavement, edge of the curb ramp, as shown on the signal plans. Make the top of the foundation flush with any adjacent sidewalk or concrete area, except where the ground rises steeply behind the sidewalk or concrete area. In this case, match the back side of the foundation to the ground slope and set the street side of the foundation above the sidewalk or concrete area and completely out of the sidewalk or concrete area. Edge the pole foundation top using a 1/2-inch sidewalk edger and do not chamfer.

Install anchor bolts in the angular position shown in the plans. Install a minimum of two 2-inch conduit ells, used or unused, in each pole foundation.

Excavate for foundations using an earth auger to specified dimensions according to 503.04. Exercise caution when excavating in areas of underground installations to avoid their disturbance or damage. When a cave-in occurs or at the direction of the Engineer, excavate using casing, sleeving, or other methods, with the Engineer's approval according to 732.10. If subsurface obstructions are encountered, remove the obstructions, or replace the excavated material and relocate the foundation, with the Engineer's approval. If bedrock is encountered, the Contractor may reduce that portion of the specified foundation depth within the bedrock up to 50 percent. Perform all necessary dewatering of the excavation.

Perform foundation concrete work according to Item 511, except that the loading restrictions in 511.17 are modified by this subsection. Place the concrete against undisturbed soil or compacted embankment. Form the top of the foundations to a nominal depth of 6 inches below the groundline. Place the concrete foundation, including formed top, in one continuous concrete pour.

For foundations for anchor base type supports, provide the required reinforcing rods, and have anchor bolts and conduit ells accurately held by a template.

Remove forms and templates once the concrete has hardened sufficiently so as not to be susceptible to damage. After 14 days, erect and load supports on anchor base foundations. The Contractor may erect and load supports after 7 days if the tests of two beam specimens of concrete yield an average modulus of rupture of not less than 650 pounds per square inch.

632.15 Signal Support. Furnish supports with mast arms with the required pole and arm length, anchor bolt circle diameter, and anchor bolt size.

Ensure that the combination signal supports with light pole extension provide for the attachment of a luminaire bracket arm.

For support designs not specifically shown on the plans, demonstrate, to the Engineer's satisfaction, that supports are structurally equivalent to the specified design.

Do not use concrete grouting in the space between the foundation surface and support base.

Conform to the requirements of 630.06 for threaded fasteners, anchor bolts, anchor bolt nuts, and anaerobic adhesive.

632.16 Strain Pole. Furnish strain poles for the attachment of messenger wire with the required pole length. Use anchor base type strain poles. Adjust anchor base type poles with the initial rake so that when loaded the poles assume an essentially vertical position.

Ensure that the combination strain poles with light pole extension provide for the attachment of a luminaire bracket arm.

Conform to the requirements of 630.06 for threaded fasteners, anchor bolts, anchor bolt nuts, and anaerobic adhesive.

Do not erect signal supports unless at least one signal, sign or dampening devise approved by the Engineer is installed within 24 hours.

632.17 Wood Pole. Set wood poles in holes excavated by an earth auger to a minimum depth of 6 feet. Use an auger with a diameter approximately 4 inches greater than the pole butt. Hold poles with initial rake, up to a maximum of 12 inches, while tamping backfill into place, so that under messenger wire tensioning conforming to 632.22, the poles assume an essentially vertical position. Furnish backfill material no greater than 1 inch in size, and thoroughly tamp material in lifts not exceeding 6 inches, to the satisfaction of the Engineer. If concrete embedment is specified, brace the poles until the concrete has set.

Liberally coat field holes bored for the attachment of messenger or guy wire with approved creosote base paint and fitted with 5/8-inch thimble-eye through-bolts and 3-inch washers. Securely attach and protect ground wire furnished as part of another work item with a wood or plastic molding for a minimum distance of 10 feet above groundline.

632.18 Down Guy Assembly. Install and tension guy assemblies before erecting signals such that they will resist the major portion of the horizontal loading caused by loading of the messenger wire.

632.19 Pedestal. Furnish pedestals for the support of traffic control equipment with a transformer type base, unless a cast or plate steel base is specified.

632.20 Conduit Riser. Attach risers to poles to provide a wiring raceway and include a weatherhead, conduit, necessary fittings, and pole attached clamps. Attach risers to poles by clamps spaced at intervals not exceeding 5 feet. Paint conduit risers mounted on painted poles to match the poles.

632.21 Cable Support Assembly. Use cable support assemblies to eliminate strain on cables, or groups of cables up to a maximum of four, entering the interior of poles through a weatherhead or mast arm. If required, include a length of messenger wire forming a sling with ends formed of lapped wire, thimbles, and clamps as part of the assembly.

632.22 Messenger Wire. Arrange messenger wire with accessories between two or more poles to provide support and attachment for traffic control equipment. Accessories used with messenger wire include bullrings, thimbles, preformed guy grip dead ends, and three bolt clamps. Furnish bullrings at messenger wire network corners. Use thimbles to attach messenger wire to the shackles of strain pole clamps and bullrings.

Adjust the length of the messenger wire under the load of traffic control equipment so the sag at the lowest point is not greater than 5 percent or less than 3 percent of the span. Attach signal cable to messenger wire with lengths of preformed helical lashing rod that are of a proper internal diameter to tightly secure the cable to the messenger wire. Attach interconnect cable with preformed lashing rod or spinning wire.

632.225 Tether Wire. Arrange tether wire with accessories to stabilize signal heads and prevent excessive swinging. Accessories included with tether wire include anchor shackles, S-hooks yielding element, thimbles, turnbuckles, guy grips, wire rope clips, lock wire, safety tie wire, lead sheet, and signal head tether anchors and extenders.

Adjust the tether span to be horizontal on simple spans. On complex spans, the tether span shall be essentially parallel to the overlying messenger span. Use Bull Rings at all internal corners of the tether span. Install safety ties at all yielding (S-hook) locations to prevent the span end from dropping into the roadway if the S-hook opens. Do not attach electrical or communication cables of any kind to the tether wire. Do not suspend from, or attach to, the tether wire any signs or other devices.

632.23 Cable and Wire. Fashion cable at traffic signal equipment weatherhead entrance fittings into a drip loop that extends at least 6 inches below the entrance. Do not allow the cable to chafe on the equipment. Support cables installed in strain poles and signal supports with cable support assemblies according to 632.21.

Do not use splices in any cable or wire, except at the following locations:

A. At the junction of detector wire and lead-in cable.

B. At the junction of power cable and the power supply source or service cable.

For splices allowed in aerial installations, accomplish splicing in weather tight splice enclosures. For splices allowed in underground installations, accomplish splicing in pull boxes or poles where the splice is encapsulated with poured waterproof epoxy insulation according to 725.15.

Install signal cable between signal heads and controller cabinets as per Table 632.23-1. Install interconnect cable between controller cabinets of different intersections, between an interconnect device and a controller cabinet, or between interconnect devices at different locations, depending on the type of interconnect cable and the design shown in the plans. Route signal and interconnect cable by aerial installation supported by messenger wire or within underground conduit. Do not install signal cable and interconnect cable on the same messenger wire. Ground the supporting messenger wire of interconnect cable.

TABLE 632.23-1 FIELD WIRING HOOKUP

PED UNIT FIELD WIRING HOOKUP

PED UNIT LOCATION	CROSSWALK DISPLAY	WIRE COLOR
SOUTH CROSSWALK	WALK	BLACK
	DONT WALK	ORANGE
WEST CROSSWALK	WALK	GREEN
	DONT WALK	RED
NORTH CROSSWALK	WALK	BLUE
	DONT WALK	WHITE W/BLACK TRACER
EAST CROSSWALK	WALK	GREEN W/BLACK TRACER
	DONT WALK	RED W/BLACK TRACER

SIGNAL HEAD & CABINET FIELD WIRING HOOKUP

SIGNAL DISPLAY	WIRE COLOR PER APPROACH
THRU R	RED
THRU Y	ORANGE
THRU G	GREEN
L/T R	BLACK (FUTURE USE ONLY)
L/T Y	WHITE W/BLACK TRACER
L/T G	BLUE
R/T R	NOT USED BY CITY
R/T Y	RED W/BLACK TRACER
R/T G	GREEN W/BLACK TRACER

WHITE SHALL BE USED FOR THE COMMON. SPLICE ALL WIRES IN THE SIGNAL HEAD OR PED UNIT. USE A #14 AWG 2 WIRE SPADE TERMINAL FOR EVERY 2 WIRES PER CONNECTION AND A #14 AWG 1 WIRE SPADE TERMINAL FOR EACH SINGLE WIRE CONNECTION TO CONNECT ALL WIRES TO ALL FIELD TERMINALS. USE BUTT SPLICES ON ALL THROUGH WIRES. ALL UNUSED WIRES SHALL BE SPLICED THROUGH AND SHALL HAVE A DEAD-END TERMINAL AT THE END OF THE WIRE.

Provide loop detector wire consisting of detector wire inserted into flexible polyethylene tubing. Ensure that the tubing encases the wire continuously from the splice at the lead-in cable, through the entire loop turns, and back to the splice. Install loop detector wire in sawn roadway slots forming loops according to 632.11. Furnish the required number of turns of wire installed for each loop, and push the wire carefully into the slots with a blunt tool to avoid damaging the tubing. Run the wire continuously around the loop perimeter and through a slot leading to the pavement edge and by underground conduit to a roadside pull box or pole with 5 feet at each end for slack and splice. Uniformly twist wires and tubing installed in the conduit to the splice with lead-in cable at 3 to 5 turns per foot. Splice the loop ends to lead-in cable, which is connected to the controller cabinet. Join the wires by a mutually twisted in-line splice, rosin core soldered, and wrapped in vinyl or equivalent electrical tape, and encapsulate wires with an approved poured waterproof epoxy insulated splice according to 725.15. Extend and seal the tubing ends into the poured epoxy splice. Also, solder crimped terminals to the conductors and the shield for connections inside the cabinet.

Route lead-in cable within underground conduit or by aerial installation supported by messenger wire.

Install power cable from the power supply source to the controller cabinet or from terminus of service cable to controller cabinet when service cable is used. If multi-conductor power cable is specified, the Contractor may substitute multiple single conductors.

Install service cable aerially from a remote power source to the vicinity of the controller cabinet with the support cable functioning as the electrical neutral. Furnish connections used with aluminum power or service cable of an approved type for aluminum to aluminum or aluminum to copper connections, and insulate connections with an approved vinyl mastic pad.

632.24 Power Service. Furnish and install all equipment necessary to provide complete 120VAC, single-phase electrical power service to each signal installation as shown on the plans. Supply power from the approximate location as shown on the plans. Make all necessary arrangements with the local electrical power company for connections to establish electrical service. Contact the power company a minimum of four (4) work weeks prior to the need for power.

If a transformer has to be installed to supply power to the signal, make arrangements with the power company to have a pad-mounted or pole-mounted transformer installed as indicated in the plans. Contact the power company a minimum of 16 weeks prior to the need for the transformer.

Charges made by the power company for establishing of the account, extension of company facilities, purchase and installation of a transformer, connection of customer equipment to the power company facilities and energy will be borne by the Contractor.

632.25 Covering of Vehicular and Pedestrian Signal Heads. Cover all signal heads and pushbuttons along with their signs that are installed prior to being used to control traffic or pedestrians. Use only canvass fabric to cover signal heads. Securely lash down the covers so the wind does not rip them from the signal head. Keep covered signal heads dark by disconnecting power to the signal indications. No covered head shall block the view of an operating head. Immediately remove or cover existing vehicular or pedestrian heads that are not functional. Maintain covers, and remove and dispose of them when directed by the Engineer.

632.26 Removal of Traffic Signal Installation. Remove signal heads, cable, messenger wire, strain poles, cabinet, controller, or other incidental items required by the Engineer. Remove support foundations in their entirety. If nearby obstructions or utilities do not allow this, and the Engineer approves, remove the foundation to at least 1 foot below subgrade or 2 feet below finished groundline, whichever is greater. Backfill, restore surfaces, and dispose of surplus material according to 603.12. Store removed items on the project for delivery to the City, or reuse removed items as part of a new installation on the project under another item of work. Dispose of all items not designated for salvage or reuse. As specified in 614.03, do not remove signals until a new signal system or a temporary traffic control method approved by the Engineer is in operation. Suitably protect stored equipment.

Contact the Division of Planning and Operations Traffic Maintenance Manager twenty-four (24) hours, not including Saturday, Sunday, or City holidays, in advance to schedule delivery. No item will be accepted without following this procedure. The Traffic Maintenance Manager will inspect the condition of all salvaged items being

presented for delivery. The Traffic Maintenance Manager will not accept items damaged by the Contractor. Do not consider any item as being delivered until the Traffic Maintenance Manager issues a receipt to the Contractor acknowledging acceptance of delivery.

632.27 Reuse of Traffic Signal Equipment. Reinstall or re-erect specified traffic equipment, removed from existing signal installations within the project. Clean and restore reused equipment to an operating condition. Furnish all additional hardware and incidentals necessary to allow reuse of the equipment.

632.28 Testing.

A. General. Furnish all personnel and equipment required to successfully perform the following tests, and furnish to the Engineer six certified copies of complete test records, test reporting forms supplied by the Engineer, or alternate certification approved by the Engineer.

B. Ground Test. Measure each ground rod for earth resistance according to 625.16 and 625.19, except that measurements are not necessary immediately after installation.

C. Short-Circuit Test. Before performing any cable insulation tests or performance test, perform a short-circuit test with a volt-ohmmeter or other approved instrument. Conduct short-circuit tests with electrical loads, power sources, equipment grounds, and earth grounds disconnected. Test signal cable routed to signal heads with connections made to lamp sockets without lamps installed. Measure each conductor against every other conductor and ground to ensure that no short-circuits, cross-circuits, or other improper connections exist. Ensure that continuity does not exist between any conductor and another conductor including ground.

D. Circuit Continuity Test. Temporarily jumper each circuit branch at its termination and the temporarily looped circuit measured for continuity to ensure that no open circuits exist, that the circuit branch is according to plan, that no high resistance connections exist, and that each circuit is properly identified. Test the lead-in cable for loop detector wire before and after splicing the cable to the loop wire. As an alternative, perform the circuit continuity testing of signal head cable by applying 120 volts to each outgoing circuit and observing that only the proper lamps are lighted.

E. Cable Insulation Test. Ensure that the insulation resistance measured to ground is not less than 10 megohms for each conductor of cable or wire terminating at the controller cabinet. Perform insulation testing with all conductors disconnected from their points on the terminal blocks. Measure insulation resistance for the wire of roadway loops after the embedding of the wire with sealant in slots. Include a list of the resistance readings for each conductor in the test results. After completing the cable insulation test, connect all cabinet wiring according to the wiring diagram. Demonstrate to the satisfaction of the Engineer that all circuits are continuous and operating correctly with freedom from shorts, crosses, and unintentional grounds.

F. Functional Test (Contractor Testing of Electronic Signal Components Before Primary Power Installation). If any testing of the signal installation or any aspect thereof is planned prior to an approved flash or signal turn-on, notify the Division of Design and Construction, Construction Section, Traffic Signal Construction Coordinator twenty-four (24) hours, not including Saturday, Sunday, or City holidays in advance and have a special duty officer present for the test to control traffic as needed. Have testing

and/or troubleshooting performed by an IMSA Level Two certified technician. If portable power is used, properly connect it to a ground rod reading 10 ohms or less and have a proper regulating device to smooth current. Before the 10-day performance test begins, make the following checks and demonstrate to the Engineer that the system is ready for the performance test. Ensure that the incoming AC voltage is a nominal 120 volts. If the supplied voltage under load is less than 100 or more than 130 VAC, contact the power company to arrange correction. Ensure that the cabinet ventilating fan, fan thermostat, and convenience outlet with lamp is operational. Correct timing settings on the controller as shown on the plans. Check all cabinet switches including the power on/off switch and flash switch. Check all controller functions to verify correct operation. Check the detector units to determine which pavement loop is associated with which detector unit. Check the visual indication of detector units to determine that each vehicle class (truck, car, or motorcycle) entering sensor areas is detected on the associated detector unit and that no extraneous calls occur when the sensor area is vacant. Check the flash switch to verify transfer of signal operation to flash and return to stop-and-go. Check the conflict monitor to verify that it is not activated by normal signal operations or by the manipulation of cabinet switches. If the monitor is activated, determine the cause of the problem and make appropriate changes and adjustments before beginning the performance test. Test the conflict monitor by artificially causing a number of different conflicting indications, and verify that at each test the monitor causes the signals to begin flashing and places the controller in a "stop timing" mode. Obtain artificial causation either by touching a jumper wire between two conflicting load switch outputs or by other methods approved by the Engineer. Ensure that the signal flashes when the monitor is disconnected.

G. Performance Test (Ten Day Test). The Division of Design and Construction requires a ten day test to start after the signal installation is 100% complete which includes establishing data communications if present. The Division will not allow partial tests. At least 7 days before the performance test begins, submit a written request to the Engineer at 1800 East 17th Avenue, Columbus, Ohio, 43219 stating that the signal installation is 100% complete and a start date for the ten day test is requested. The Division of Design and Construction, Construction Section, will monitor the test and will be the sole agency to accept the signal installation on behalf of the City. If less than 100% completion is detected upon inspection by this Division or any malfunction is detected, completely restart the ten day test.

Before acceptance, operate the traffic control system continuously for 10 consecutive days without major malfunction or failure. Immediately replace or repair minor failures (such as lamps, a single detector unit, or an individual signal head, etc.) that do not cause restart of the test. Major malfunctions or failures (such as a master or local controller, interconnect equipment, etc.) will cause termination of the test and, after replacement or repair, the beginning of a new 10-day test. Monitor items that have been repaired or that are replacements for a 10-day period to provide assurance of their reliability. Record, for inclusion in the test result, the method and date of correction of each fault, and the beginning and end of the test.

H. Cabinet Assembly Testing By the City of Columbus. The Division of Planning and Operations Electronic Systems Shop will bench test the intersection controller and its complete cabinet assembly prior to the equipment being installed in the field. Testing will not begin unless complete and correct cabinet assembly wiring schematics, loop

detector units, and if specified, the intersection transceiver unit are submitted with the cabinet. The test procedures will consist of operating the equipment for a minimum of forty-eight (48) hours. Deliver the controller and complete cabinet assembly for testing to the Division of Planning and Operations Traffic Maintenance Shop at 1820 East 17th Avenue, Columbus, Ohio 43219. Load and unload all equipment and obtain a receipt from shop personnel that lists all delivered materials by manufacturer, model number, and serial number. The Division will complete testing on the controller and cabinet assembly within ten (10) City working days. Upon completion of the testing the Division will notify the Contractor that the equipment can be picked up. Replace, repair or correct as necessary all devices found to be unsatisfactory and resubmit for testing. The Division will schedule testing of this returned equipment as quickly as possible but will only provide a forty-five (45) day guarantee for the turn-around time period. The Contractor shall be solely responsible for any delay caused by this testing. Do not install control equipment, which has not passed testing or which has not been tested by the Division, in the field to control traffic. The Contractor may have a representative in attendance during the testing process. There are no costs associated with the testing. Any cost associated with the delivery and pick-up shall be incidental to the cost of the equipment. Contact the Division of Planning and Operations Electronic Systems Coordinator for equipment status.

632.29 Method of Measurement. The City will measure Vehicular Signal Head and Pedestrian Signal Head by the number of complete units, and will include all support or mounting hardware, disconnect hangers, closure caps, dimmers, and lamps as required. Optically programmed heads shall include programming. For programming purposes, 8-inch (200 mm) programmed heads shall include one extender tool per project.

The City will measure Pedestrian Pushbutton by the number of individual units, and will include pedestrian pushbutton signs.

The City will measure Loop Detector Unit by the number of individual units, adjusted and tuned, and will include a wiring harness.

The City will measure tether wire by the number of feet in place, and will include all necessary accessories such as anchor shackles, S-hooks yielding element, thimbles, turnbuckles, guy grips, wire rope clips, lock wire, safety tie wire, lead sheet, and signal head tether anchors and extenders. The City will measure from pole center to pole center, or pole center to bullring, or bullring to bullring. The City will not measure any length of tether wire for attachment to poles or bullrings by bending, lapping or wrapping.

The City will measure Detector Loop by the number of complete detector loops installed in the pavement, and will include pavement cutting, loop detector wire with tubing in place, application of sealant, conduit, trenching, backfilling, and surface restoration from the edge of pavement to the pull box.

The City will measure Strain Pole Foundation, Signal Support Foundation, and Pedestal Foundation by the number of complete units, and will include excavation, dewatering, sleeving, casing, reinforcing steel, anchor bolts, conduit ells, concrete, backfilling, and disposal of surplus excavation.

The City will measure Signal Support, Combination Signal Support, Strain Pole, Combination Strain Pole, Wood Pole, and Pedestal by the number of complete units of each, and will include pole arms, weather-heads, and blind half couplings.

The City will measure Sleeve for Anchor Base Foundation by the number of units furnished, installed, and properly backfilled.

The City will measure Down Guy by the number of individual units, and will include messenger wire, pole clamp or thru-bolt, washer, clamps, guy grips, insulator, guy guard, and anchor.

The City will measure Conduit Riser by the number of complete units, and will include weatherhead, conduit, fittings, clamps, and hardware.

The City will measure Messenger Wire by the number of feet (meters) in place, and will include all necessary accessories such as, grips, thimbles, clamps, bullrings, and lashing rod. The City will measure from pole center to pole center, or pole center to bullring, or bullring to bullring. The City will not measure any length of messenger wire for attachment to poles, or bullrings by bending, lapping, or wrapping.

The City will measure Signal Cable, Phone Interconnect Cable, Loop Detector Lead-In Cable, Power Cable, and Service Cable by the number of feet in place. Cable inside of poles shall include cable support assemblies. Aerial cable shall include pole attachment hardware, splices, splice enclosures, and ground connection. Lead-in cable shall include poured epoxy insulated splices. The City will measure: (1) horizontally from center-to-center of pull boxes, poles, cabinets, power sources, and signal heads with an additional allowance of 5 feet at each pull box and terminating points for slack and connections; and (2) vertically between pole or conduit outlets. If single-conductor power cable is substituted for multi-conductor cable, the City will measure required length of multi-conductor cable.

The City will measure Power Service by the number of complete units, and will include, all necessary hardware, purchase and installation of transformer, installation of transformer pad when required, and ground wire connection.

The City will measure Covering of Vehicular Signal Head and Covering of Pedestrian Signal Head by the number of individual signal heads covered, and will include materials and labor to erect, maintain, and remove the covering.

The City will measure Removal of Traffic Signal Installation by the number of installations removed, and will include storage when required.

The City will measure Removal of (*Item*) and (*Storage or Reerection*) by the number of specific traffic signal installation parts (such as a signal head, controller unit, or pole) removed, and will include storage when required.

The City will measure Reuse of (*Item*) by the number of traffic signal equipment items reused, and will include cleaning, and restoring.

632.30 Basis of Payment. The costs to arrange service by the supply agency are included under Power Cable.

The costs of personnel, materials, equipment, electrical energy, and incidentals required to conduct performance tests are included under the contract unit price for the respective items tested.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
632	Each	Vehicular Signal Head, ___-Section ___ inch Lens ___-Way (with Backplate)
632	Each	Vehicular Signal Head, Optically Programmed, ___-Section, ___ inch Lens, ___-Way (with Backplate)
632	Each	Pedestrian Signal Head
632	Each	Pedestrian Pushbutton
632	Each	Loop Detector Unit
632	Each	Detector Loop
632	Each	Strain Pole Foundation
632	Each	Signal Support Foundation
632	Each	Pedestal Foundation
632	Each	Sleeve for Anchor Bolt Foundation
632	Each	Signal Support, Type TC-___, Design ___
632	Each	Combination Signal Support, Type TC-___, Design ___
632	Each	Strain Pole, Type TC-81.10, Design ___
632	Each	Combination Strain Pole, Type TC-81.10, Design ___
632	Each	Wood Pole, Class ___, (Length)___ feet
632	Each	Down Guy
632	Each	Pedestal, (Length) ___ feet
632	Each	Pedestal, (Length) ___ feet, Transformer Base
632	Each	Conduit Riser, ___ inch Dia.
632	Foot	Messenger Wire, (No.) Strand ___ inch Dia., with Accessories
632	Foot	Signal Cable, ___- Conductor, ___ AWG
632	Foot	Interconnect Cable, ___- Conductor, ___ AWG
632	Foot	Loop Detector Lead-In Cable
632	Foot	Power Cable, ___- Conductor, ___ AWG
632	Foot	Service Cable, ___- Conductor, ___ AWG
632	Each	Power Service
632	Each	Covering of Vehicular Signal Head
632	Each	Covering of Pedestrian Signal Head
632	Each	Removal of Traffic Signal Installation
632	Each	Removal of (Item) and (Storage Or Reerection)
632	Each	Reuse of (Item)
632	Foot	Tether Wire, with Accessories