CITY OF BRYAN, TEXAS

TECHNICAL SPECIFICATIONS FOR TRAFFIC SIGNAL INSTALLATIONS

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TRAFFIC SIGNAL INSTALLATIONS

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ITEM 618
CONDUIT

618.1. Description. Furnish and place conduit.

618.2. Materials. Provide new materials that comply with the details shown on the plans, the requirements of this Item, and the pertinent requirements of Item 622, "Duct Cable."

When specified in the plans, provide:

- rigid metal (RM) conduit that is hot-dip galvanized inside and outside with a minimum of 1.5 oz. per square foot of a zinc coating in accordance with Item 445, "Galvanizing";
- electrical metallic tubing (EMT) and intermediate metal conduit (IMC) that is steel, galvanized on the outside, and protected on the inside with a suitable corrosion-resistant material;
- polyvinyl chloride (PVC) conduit that meets the requirements of NEMA Standard TC-2, UL 651, and the NEC;
- high-density polyethylene (HDPE) conduit without factory-installed conductors that meets the requirements of Item 622, "Duct Cable"; or
- flexible conduit that is liquid-tight.

Furnish conduit from new materials that comply with DMS-11030, "Conduit."

Provide conduit from manufacturers prequalified by the Department. The Traffic Operations Division maintains a list of prequalified electrical conduit manufacturers.

Unless otherwise shown on the plans, fabricate fittings such as junction boxes and expansion joints from a material similar to the connecting conduit. Use watertight fittings. Do not use set screw and pressure-cast fittings. Steel compression fittings are permissible. When using HDPE conduit, provide fittings that are UL-listed as electrical conduit connectors or thermally fused using an electrically heated wound wire resistance welding method.

Use red 3-in. 4-mil polyethylene underground warning tape that continuously states "Caution Buried Electrical Line Below."

618.3. Construction. Place conduit in accordance with the lines, grades, details, and dimensions shown on the plans or as directed. Install conduit a minimum of 18 in. deep underground unless otherwise shown on the plans. Meet the requirements of the NEC when installing conduit. Secure and support conduit placed for concrete encasement in such a manner that the alignment will not be disturbed during placement of the concrete. Cap ends of conduit and close box openings before concrete is placed.

Ream conduit to remove burrs and sharp edges. Use a standard conduit cutting die with a 3/4-in. taper per foot when conduit is threaded in the field. Fasten conduit placed on structures with conduit straps or hangers as shown on the plans or as directed. Fasten conduit within 3 ft. of each box or fitting and at other locations shown on the plans or as directed. Use metal conduit clamps that are galvanized malleable or stainless steel unless otherwise shown on the plans. Use 2-hole type clamps for 2-in. diameter or larger conduit.

Fit PVC and HDPE conduit terminations with bushings or bell ends. Fit metal conduit terminations with a grounding type bushing, except conduit used for duct cable casing that does not terminate in a ground box and is not exposed at any point. Conduit terminating in threaded

bossed fittings does not need a bushing. Prior to installation of conductors or final acceptance, pull a spherical template having a diameter of at least 75% of the inside diameter of the conduit through the conduit to ensure that the conduit is free from obstruction. Cap or plug empty conduit placed for future use.

Perform trench excavation and backfilling as shown on the plans or as directed and in accordance with Item 400, "Excavation and Backfill for Structures." Excavation and backfilling will be subsidiary to the installation of the conduit.

Jack and bore as shown on the plans or as directed, and in accordance with Item 476, "Jacking, Boring, or Tunneling Pipe."

Place warning tape approximately 10 in. above trenched conduit. Where existing surfacing is removed for placing conduit, repair by backfilling with material equal in composition and density to the surrounding areas and by replacing any removed surfacing, such as asphalt pavement or concrete riprap, with like material to equivalent condition. Mark conduit locations as directed.

618.4. Measurement. This Item will be measured by the foot of conduit.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2, "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

618.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Conduit" of the type and size specified and the installation method specified as applicable. This price is full compensation for furnishing and installing conduit; hanging, strapping, jacking, boring, tunneling, excavating, and furnishing and placing backfill; replacing pavement structure, sod, riprap, curbs, or other surface; marking location of conduit (when required); furnishing and installing fittings, junction boxes, and expansion joints; and equipment, labor, tools and incidentals.

Flexible conduit will not be paid for directly but will be subsidiary to pertinent Items. Unless otherwise shown on the plans, no payment will be allowed under this Item for conduit used on electrical services or in foundations.

END OF SECTION

ITEM 620
ELECTRICAL CONDUCTORS

620.1. Description. Furnish and place electrical conductors, except conductors specifically covered by other Items.

620.2. Materials. Provide new materials that comply with the details shown on the plans and the requirements of this Item. Use stranded insulated conductors that are rated for 600 volts; approved for wet locations; and marked in accordance with UL, NEC, and CSA requirements. Furnish electrical conductors in accordance with DMS-11040, "Electrical Conductors."

Provide electrical conductors from manufacturers prequalified by the Department. The Traffic Operations Division maintains a list of prequalified electrical conductor manufacturers.

Ensure that all grounding conductors size AWG No. 8 and larger are stranded, except for the grounding electrode conductor, which will be a solid conductor.

Use white insulation for grounded (neutral) conductors, except that grounded conductors AWG No. 8 and larger may be black with white tape marking at every accessible location. Do not use white insulation or marking for any other conductor except control wiring specifically shown on the plans.

Ensure that insulated grounding conductors are green except that insulated grounding conductors AWG No. 8 and larger may be black with green tape marking at every accessible location. Do not use green insulation or marking for any other conductor except control wiring specifically shown on the plans.

620.3. Construction. Splice conductors only in junction boxes, ground boxes, and transformer bases, and in poles and structures at the hand holes. Splice as shown on the plans. Do not exceed the manufacturer's recommended pulling tension. Use lubricant as recommended by the manufacturer. Install conductors in accordance with the NEC.

Make insulation resistance tests on the conductors prior to making final connections, and ensure that each continuous run of insulated conductor has a minimum DC resistance of 5 megohms when tested at 1,000 volts DC. The Engineer may require verification testing of all or part of the conductor system. The Engineer will witness these verification tests. Replace conductors exhibiting an insulation resistance of less than 5 megohms.

620.4. Measurement. This Item will be measured by the foot of each single conductor.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2, "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

620.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Electrical Conductors" of the types and sizes specified. This price is full compensation for furnishing, installing, and testing electrical conductors and for equipment, labor, tools, and incidentals, except that:

- conductors used in connecting the components of electrical services will be paid for under Item 628, “Electrical Services”;
- conductors inside roadway illumination assemblies will be paid for under Item 610, “Roadway Illumination Assemblies”; and
- conductors used for internal wiring of equipment will not be paid for directly but will be subsidiary to pertinent Items.

END OF SECTION

ITEM 624
GROUND BOXES

624.1. Description. Construct, furnish, and install ground boxes complete with lids.

624.2. Construction and Materials. Provide new materials that comply with the details shown on the plans and meet the following requirements:

- Construct cast-in-place concrete ground boxes and aprons in accordance with Item 421, "Hydraulic Cement Concrete," and Item 440, "Reinforcing Steel."
- Provide fabricated precast polymer concrete ground boxes, and precast concrete ground boxes that comply with DMS-11070, "Ground Boxes."
- Construct a concrete apron, when shown on the plans, in accordance with Item 421, "Hydraulic Cement Concrete," and Item 440, "Reinforcing Steel."

Provide ground boxes from manufacturers prequalified by the Department. The Traffic Operations Division maintains a list of prequalified ground box manufacturers.

624.3. Measurement. This Item will be measured by each ground box complete in place.

624.4. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Ground Boxes" of the types and sizes specified. This price is full compensation for excavating and backfilling; constructing, furnishing, and installing the ground boxes and concrete aprons when required; and equipment, labor, materials, tools, and incidentals.

END OF SECTION

ITEM 628
ELECTRICAL SERVICES

628.1. Description.

- **Installation.** Furnish and install complete and independent points of electrical service.
- **Removal.** Remove electrical services.

628.2. Materials. Provide materials that comply with the details shown on the plans, the requirements of this Item, and the pertinent requirements of the following Items:

- Item 441, "Steel Structures"
- Item 445, "Galvanizing"
- Item 449, "Anchor Bolts"
- Item 618, "Conduit"
- Item 620, "Electrical Conductors"
- Item 627, "Treated Timber Poles"
- Item 656, "Foundations for Traffic Control Devices."

For the installation of electrical services, use new materials that meet the requirements of the NEC, UL, CSA, and NEMA, and that comply with DMS-11080, "Electrical Services."

Furnish electrical services from manufacturers prequalified by the Department. The Traffic Operations Division maintains a list of prequalified electrical service manufacturers.

628.3. Construction. Perform work in accordance with the details shown on the plans and the requirements of this Item.

A. Installation. Ensure components of the electrical service meet the requirements of the Electrical Detail Standards. Follow NEC and local utility company requirements when installing the electrical equipment.

Coordinate the utility companies' work for providing service.

B. Removal. Coordinate removal with the appropriate utility company before beginning work. Before the removal of the electrical service, disconnect and isolate any existing electrical service equipment in accordance with the utility company's requirements.

Use established industry and utility safety practices while removing electrical service equipment near any overhead utilities.

Remove existing electrical service support a minimum of 2 ft. below finish grade unless otherwise shown on the plans. Repair the remaining hole by backfilling with material equal in composition and density to the surrounding area. Replace any surfacing such as asphalt pavement or concrete riprap with like material to equivalent condition.

Disconnect conductors and remove them from the conduit or duct. Cut off all protruding conduit or duct 6 in. below finish grade. Abandoned conduit or duct need not be removed unless shown on the plans.

Reconnect duct cable, conductors, and conduit to be reused when shown on the plans. Make all splices in ground boxes unless otherwise shown on the plans.

Accept ownership of unsalvageable materials, and dispose of them in accordance with federal, state, and local regulations.

628.4. Measurement. This Item will be measured by each electrical service installed or removed.

628.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Electrical Services" of the types specified or "Remove Electrical Services."

A. Installation. This price is full compensation for paying all fees, permits, and other costs; making arrangements with the utility company for all work and materials provided by the utility company; furnishing, installing, and connecting all components including poles, service supports, foundations, anchor bolts, riprap, enclosures, switches, breakers, conduit (from the service equipment including the elbow below ground), fittings, conductors (from the service equipment including the elbow below ground), brackets, bolts, hangers, and hardware; and equipment, labor, tools, and incidentals.

Costs for utility-owned power line extensions, connection charges, meter charges, and other charges will be paid for by the Department in accordance with Article 9.5, "Force Account." The Department will reimburse the contractor only the amount billed by the utility. No additional amount for supervision of the utility's work will be paid.

B. Removal. This price is full compensation for coordinating with the utility company to disconnect and isolate the electrical service; removing the service supports; backfilling holes; and equipment, labor, tools, and incidentals.

END OF SECTION

ITEM 680
INSTALLATION OF HIGHWAY TRAFFIC SIGNALS

680.1. Description. Install highway traffic signals.

680.2. Materials. Ensure electrical materials and construction methods conform to the current NEC and additional local utility requirements. Furnish new materials. Ensure all materials and construction methods conform to the details shown on the plans, the requirements of this Item, and the pertinent requirements of the following Items:

- Item 610, "Roadway Illumination Assemblies"
- Item 625, "Zinc-Coated Steel Wire Strand"
- Item 627, "Treated Timber Poles"
- Item 634, "Plywood Signs"
- Item 636, "Aluminum Signs"
- Item 656, "Foundations for Traffic Control Devices."

Provide controller assemblies that meet the requirements of DMS-11170, "Traffic Signal Controller Assembly," and the details shown on the plans.

Provide controller assemblies from manufacturers prequalified by the Department. The Traffic Operations Division maintains a list of prequalified controller assembly manufacturers.

Provide flasher assemblies that meet the requirements of DMS-11160, "Flasher Controller Assembly," and the details shown on the plans.

Provide flasher assemblies from manufacturers prequalified by the Department. The Traffic Operations Division maintains a list of prequalified flasher assembly manufacturers.

Sampling and testing of traffic signal controller assemblies will be done in accordance with Tex-1170-T.

680.3. Construction. Install traffic signal controller foundations in accordance with Item 656, "Foundations for Traffic Control Devices."

A. Electrical Requirements.

1. **Electrical Services.** Make arrangements for electrical services and install and supply materials not provided by the utility company as shown on the plans. Unless otherwise shown on the plans, install 120-volt, single-phase, 60-Hz AC electrical service.
2. **Conduit.** Install conduit and fittings of the sizes and types shown on the plans. Conduit of larger size than that shown on the plans may be used with no additional compensation, providing that the same size is used for the entire length of the conduit run. Extend conduit in concrete foundations 2 to 3 in. above the concrete. Seal the ends of each conduit with silicone caulking or other approved sealant after all cables and conductors are installed.
3. **Wiring.** Unless otherwise shown on the plans, furnish stranded No. 12 AWG XHHW conductors. Install above-ground cables and conductors in rigid metal conduit, except for span wire suspended cables and conductors, drip loops, and electrical wiring inside signal poles. Make power entrances to ground-mounted controllers through underground conduit. Wire each signal installation to operate as shown on the plans.

   Attach ends of wires to properly sized self-insulated solderless terminals. Attach terminals to the wires with a ratchet-type compression crimping tool properly

sized to the wire. Place prenumbered identification tags of plastic or tape around each wire adjacent to wire ends in the controller and signal pole terminal blocks.

Splices will not be permitted except as shown on the plans, unless the Engineer approves each individual splice in writing. Make all allowed splices watertight.

4. **Grounding and Bonding.** Ground and bond conductors in accordance with the NEC. Ensure the resistance from the grounded point of any equipment to the nearest ground rod is less than 1 ohm.

   Install a continuous bare or green insulated copper wire (equipment ground) throughout the electrical system that is the same size as the neutral conductor, but a minimum No. 8 AWG. Connect the equipment ground to all metal conduit, signal poles, controller housing, electrical service ground, ground rods, and all other metal enclosures and raceways.

   Provide copper wire bonding jumpers that are a minimum No. 8 AWG.

B. Controller Assemblies. Construct controller foundations in accordance with Item 656, "Foundations for Traffic Control Devices." Immediately before mounting the controller assembly on the foundation, apply a bead of silicone caulk to seal the cabinet base. Seal any space between conduit entering the controller and the foundation with silicone caulk.

Deliver the keys for the controller cabinets to the Engineer when the contract is complete.

Place the instruction manual and wiring diagrams for all equipment in the controller cabinet, inside the controller cabinet.

C. Timber Poles. Furnish ANSI Class 2 timber poles other than for electrical services in accordance with details shown on the plans.

D. Preservation of Sod, Shrubbery, and Trees. Replace sod, shrubbery, and trees damaged during the Contract.

E. Removal and Replacement of Curbs and Walks. Obtain approval before cutting into or removing walks or curbs not shown on the plans to be removed or replaced. Restore any curbs or walks removed equivalent to original condition after work is completed, to the satisfaction of the Engineer.

F. Sign Lighting. Attach sign lighting to traffic signal equipment as shown on the plans.

G. Intersection Illumination. Construct luminaires on signal poles as shown on the plans.

H. Test Period. Operate completed traffic signal installations continuously for at least 30-days in a satisfactory manner. If any Contractor-furnished equipment fails during the 30-day test period, repair or replace that equipment. This repair or replacement, except lamp replacement, will start a new 30-day test period.

Replace materials that are damaged or have failed prior to acceptance.

Replace failed or damaged existing signal system components when caused by the Contractor. The Department will relieve the Contractor of maintenance responsibilities upon passing a 30-day performance test of the signal system and acceptance of the contract.

680.4. Measurement. This Item will be measured as each signalized intersection controlled by a single traffic signal controller.

680.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Installation of Highway Traffic Signals" of the type (isolated, system, or flashing beacon) specified. This price is full compensation for furnishing, installing, and testing the completed installation, controller and associated equipment, controller foundations, luminaires, signs and sign lights mounted on signal equipment, timber poles, mounting hardware and steel wire strand; preservation and replacement of damaged sod, shrubbery and trees; removal and replacement of curbs and walks; and equipment, labor, tools, and incidentals. The Department will pay for electrical energy consumed by the traffic signal.

New drilled shaft foundations for traffic signal poles will be paid for under Item 416, "Drilled Shaft Foundations." New conduit will be paid for under Item 618, "Conduit." New electrical conductors will be paid for under Item 620, "Electrical Conductors." New ground boxes will be paid for under Item 624, "Ground Boxes." New electrical services will be paid for under Item 628, "Electrical Services." New vehicle and pedestrian signal heads will be paid for under Item 682, "Vehicle and Pedestrian Signal Heads." New traffic signal cables will be paid for under Item 684, "Traffic Signal Cables." New traffic signal pole assemblies will be paid for under Item 686, "Traffic Signal Pole Assemblies (Steel)." New traffic signal detectors will be paid for under Item 688, "Pedestrian Detectors and Vehicle Loop Detectors."

END OF SECTION

ITEM 682
VEHICLE AND PEDESTRIAN SIGNAL HEADS

682.1. Description. Furnish and install vehicle and pedestrian signal heads.

682.2. Materials. Furnish only new materials.

A. Definitions.

1. **Back Plate.** A thin strip of material extending outward from all sides of a signal head.
2. **Incandescent Optical Unit.** The lens, reflector, lamp, lamp receptacle, and associated supporting parts in a signal section.
3. **LED Optical Unit.** The LED lens and associated supporting parts in a signal section.
4. **Louver.** A device mounted to the visor restricting signal face visibility.
5. **Signal Section.** One housing case, housing door, visor, and optical unit.
6. **Signal Face.** One section or an assembly of 2 or more sections facing one direction.
7. **Signal Head.** A unidirectional face or a multidirectional assembly of faces, including back plates and louvers when required, attached at a common location on a support.

B. General. Provide vehicle signal heads in accordance with DMS-11120, "Vehicle Signal Heads." Provide vehicle signal heads from manufacturers prequalified by the Department. The Traffic Operations Division maintains a list of prequalified vehicle signal head manufacturers.

Provide pedestrian signal heads in accordance with DMS-11130, "Pedestrian Signal Heads." Provide pedestrian signal heads from manufacturers prequalified by the Department. The Traffic Operations Division maintains a list of prequalified pedestrian signal head manufacturers.

Supply either aluminum or polycarbonate signal head components that are of the same material and manufacturer for any one project.

Use galvanized steel, stainless steel, or dichromate sealed aluminum bolts, nuts, washers, lock washers, screws, and other assembly hardware.

When dissimilar metals are used, ensure the metals are selected or insulated to prevent corrosion.

Use closed-cell silicone or closed-cell neoprene gaskets.

682.3. Construction.

A. Assembly. Assemble individual signal sections in multi-section faces in accordance with the manufacturer's recommendations to form a rigid signal face. Assemble and mount signal heads as shown on the plans. Install louvers and back plates in accordance with the manufacturer's recommendations. Close any openings in an assembled signal head with a plug of the same material and color as the head.

When installing a retrofit replacement LED traffic signal or pedestrian signal lamp unit into an existing signal housing, only remove the existing lens, reflector, and incandescent lamp; fit the new unit securely in the housing door; and connect the new housing unit to the existing electrical wiring or terminal block by means of simple connectors.

B. Wiring. Wire each optical unit to the terminal block located in that signal section by means of solderless wire connectors or binding screws and spade lugs. Wire all sections of a multi-section signal face to the section terminal blocks in which the traffic signal cable is terminated. Maintain the color coding on leads from the individual optical units throughout the signal head, except for the traffic signal cable. Use solderless wire connectors or binding screws and spade lugs for connections to terminal blocks. Use binding screws and spade lugs for field wiring.

682.4. Measurement. This Item will be measured by each vehicle signal section, pedestrian signal section, back plate, or louver.

682.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Pedestrian Signal Section," "Vehicle Signal Section," "Back Plate," or "Louver," of the types and sizes specified. This price is full compensation for furnishing, assembling, and installing the signal sections, back plates and louvers, and lenses and optics; mounting attachments; and equipment, labor, tools, and incidentals.

END OF SECTION

ITEM 684
TRAFFIC SIGNAL CABLES

684.1. Description. Furnish and install traffic signal cables.

684.2. Materials. Provide polyethylene-jacketed multi-conductor cables in accordance with details shown on the plans. Individual conductors must be copper with polyethylene insulation rated for 600 volts. Furnish new materials. Provide traffic signal cables in accordance with DMS-11110, "Traffic Signal Cables."

A. Type A Cables. Use Type A cables meeting the requirements of IMSA 20-1 for underground conduit installation or for aerial cable supported by a messenger.

B. Type B Cables. Use Type B cables meeting the requirements of IMSA 20-3 as the integral messenger cable for aerial installations.

C. Type C Cables. Use Type C cables meeting the requirements of IMSA 50-2 for loop detector lead-in installations consisting of 2-conductor shielded cable.

D. Types A and B Cable Materials. Provide the following materials for Type A and B cables:

- Use the size and number of conductors shown on the plans. Unless otherwise shown on the plans, use conductors consisting of 7 copper strands.
- Ensure color coding of conductors and sequence for cables are in compliance with Table 1. Base color is the insulation color. Tracer color is the colored stripe that is part of or is firmly adhered to the insulation surface for the full length of the conductor.
- Ensure 2-conductor cable is of the round twisted type with fillers used where necessary to form a round cable.
- For cables with more than 2 conductors, ensure individual conductors are laid up symmetrically in layers with fillers used when necessary, to produce a uniform assembly of conductors with a firm compact cylindrical core.
- Ensure fillers are a non-metallic, moisture-resistant, non-wicking material.
- Supply conductor assemblies that are covered with a wrapping of a moisture-resistant tape applied to overlap at least 10% of the tape width.
- Ensure that the taped conductor assembly is covered with a tightly fitting black polyethylene jacket that is smooth and free from holes, splits, blisters, and any other imperfections.
- Supply cables that clearly show the name of the manufacturer and the IMSA specification number applied at approximate 2-ft. intervals to the outer surface of the jacket by indent printing.

Table 1 Conductor Color and Sequence for Cables		
Conductor No.	**Base Color**	**Tracer Color**
1	Black	
2	White	
3	Red	
4	Green	
5	Orange	
6	Blue	
7	White	Black
8	Red	Black
9	Green	Black
10	Orange	Black
11	Blue	Black
12	Black	White
13	Red	White
14	Green	White
15	Blue	White
16	Black	Red
17	White	Red
18	Orange	Red
19	Blue	Red
20	Red	Green
21	Orange	Green

E. Additional Requirements for Type B Cable Materials. Additional material requirements particular to Type B cable are as follows:

- Ensure cables consisting of 5 or more conductors have a 0.25-in. nominal diameter messenger. For the messenger, use Class A galvanized Extra High Strength Steel Strand with 3 or 7 wires.
- A solid strand messenger with 0.134-in. diameter may be used for cables with less than 5 conductors.
- To provide corrosion protection, ensure the messenger strand is coated and the interstices are flooded with a rubber asphalt compound or equivalent.
- Ensure the integral messenger and conductors are enclosed in the jacket forming a cross section similar to a figure 8.

F. Type C Cable Materials. Use the following materials for Type C cables:

- Unless otherwise shown on the plans, use No. 14 AWG insulated conductors with concentric stranding with black insulation on 1 of the 2 conductors and clear insulation on the other conductor.
  Ensure conductors have a minimum of 2 twists per foot within the cable.
- Use cables that have 100% shield coverage utilizing aluminum bonded to a Mylar film. Ensure the drain wire is stranded tinned copper, 2 AWG sizes less than the conductor, and in continuous contact with the aluminum side of the shield material.
- Ensure the jacket is black polyethylene.
- Use cables that legibly show the name of the manufacturer and the IMSA specification number applied at approximate 2-ft. intervals on a tape under the outer jacket.

G. Sampling. The Engineer may take samples from each roll of each size of cable for establishing conformity to IMSA. The samples will be at least 3 ft. in length. Replace any cable failing to meet IMSA requirements.

684.3. Construction. For each cable run in underground conduit, coil an extra 5 ft. of cable in each ground box.

Splices are not permitted in Type A and B cables unless shown on the plans or approved by the Engineer in writing. Ensure that splices are watertight.

Make splices between Type C cable and loop detector wires only in the ground box near the loop the cable is servicing. Use non-corrosive solder for splices. Ground the drain wire of Type C cable to earth ground only at the controller or detector cabinet. Ensure the resistance from the drain wire to the ground rod is less than 1 ohm.

Test the cables after installation and prior to any connection to the cables. Cables testing less than 50 megohms insulation resistance at 500 volts will be rejected.

684.4. Measurement. This Item will be measured by the foot of traffic signal cables.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2, "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

684.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Traffic Signal Cables" of the types and sizes specified. This price is full compensation for furnishing and installing materials and for equipment, labor, tools, and incidentals, except as shown below.

Cables inside traffic signal pole assemblies will be paid for under this Item.

Cables used for inside signal heads and controllers or for coils in ground boxes, pole bases, and on span wires will not be paid for directly but will be subsidiary to pertinent Items.

END OF SECTION

ITEM 687
PEDESTAL POLE ASSEMBLIES

687.1. Description. Furnish and install pedestal pole assemblies for vehicle and pedestrian signals.

687.2. Materials. Furnish new materials in accordance with the following items and with details shown on the plans:

- Item 445, "Galvanizing"
- Item 449, "Anchor Bolts"
- Item 656, "Foundations for Traffic Control Devices."

A. Pedestal Pole Base. Provide pedestal pole bases in accordance with DMS-11140, "Pedestal Pole Base." Provide pedestal pole bases from manufacturers prequalified by the Department. The Traffic Operations Division maintains a list of prequalified pedestal pole base manufacturers.

B. Pedestal Pole. Provide 4-in. diameter schedule 40 steel pipe or tubing, aluminum pipe (alloy 6061-T6), or rigid metal conduit. Do not use aluminum conduit. Galvanize pedestal pole assemblies in accordance with Item 445, "Galvanizing," unless otherwise shown on the plans.

687.3. Construction. Install foundations in accordance with Item 656, "Foundations for Traffic Control Devices."

A. Pedestal Pole Base. Ground the base with connectors to the 1/2-13 NC female threaded hole. Fabricate the base for 4 L-bend anchor bolts arranged in a square pattern with 12-3/4-in. bolt circle. Provide mild steel anchor bolts in accordance with Item 449, "Anchor Bolts," for each base. Provide three 1/16-in.-thick U-shaped galvanizing steel shims for each base. Size shims to fit around the anchor bolts.

B. Installation. Install pedestal pole assemblies as shown on the plans or as directed. Pedestal pole assemblies include foundation, pole shaft, base, anchor bolts, anchor bolt nuts, anchor bolt template, shims, and miscellaneous components. Watertight breakaway electrical disconnects are required for pedestal pole assemblies used in conjunction with vehicle and pedestrian heads and components.

Use established industry and utility safety practices to erect assemblies near overhead or underground utilities. Consult with the appropriate utility company prior to beginning such work.

Repair damaged galvanizing in accordance with Section 445.3.D, "Repairs."

C. Painted Finish. When required, paint pedestal pole assemblies in accordance with details shown on the plans.

687.4. Measurements. This item will be measured by each pedestal pole assembly.

687.5. Payment. The work performed and materials furnished in accordance with this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Pedestal Pole Assembly." This price is full compensation for furnishing and installing the shaft; base, shims, anchor bolts, and foundation; and materials, equipment, labor, tools, and incidentals.

New signal heads will be paid for under Item 682, "Vehicle and Pedestrian Signal Heads."

END OF SECTION

SPECIAL SPECIFICATION

6266

Video Imaging Vehicle Detection System

1. **Description.** Install a Video Imaging Vehicle Detection System (VIVDS) that monitors vehicles on a roadway via processing of video images and provides detector outputs to a traffic controller or similar device.

   A VIVDS configuration for a single intersection will consist of 4 variable focal length cameras, VIVDS card rack processor system, and all associated equipment required to setup and operate in a field environment including a video monitor and/or laptop (if required), connectors and camera mounting hardware.

   The system is composed of these principal items: the camera(s), the field communications link between the camera and the VIVDS processor unit, and the VIVDS processor unit along with a PC, video monitor or associated equipment required to setup the VIVDS and central control software to communicate to the VIVDS processor.

   The VIVDS Card Rack Processor must be either NEMA TS 2 TYPE 1 or TYPE 2. TYPE 2 must have RS 485 SDLC.

2. **Definitions**.

   A. VIVDS Processor Unit. The electronic unit that converts the video image provided by the cameras, generates vehicle detections for defined zones and collects vehicular data as specified.

   B. VIVDS Processor System. One or more VIVDS processor modular units required to handle the number of camera inputs.

   C. Central Control. A remotely located control center, which communicates with the VIVDS. The VIVDS operator at the central control has the ability to monitor the operation and modify detector placement and configuration parameters. The equipment that constitutes central control is comprised of a workstation microcomputer along with the associated peripherals as described in this special specification.

   D. Field Setup Computer. A portable microcomputer used to set up and monitor the operation of the VIVDS processor unit. If required to interface with the VIVDS processor unit, the field setup computer with the associated peripherals described in this special specification and a video monitor, also described in this special specification, must be supplied as part of the VIVDS.

   E. Field Communications Link. The communications connection between the camera and the VIVDS processor unit. The primary communications link media may be coaxial cable or fiber optic cable.

F. Remote Communications Link. The communications connection between the VIVDS processor unit and the central control.

G. Camera Assembly. The complete camera or optical device assembly used to collect the visual image. The camera assembly consists of a charged coupled device (CCD) camera, environmental enclosure, sun shield, temperature control mechanism, and all necessary mounting hardware.

H. Occlusion. The phenomenon when a vehicle passes through the detection zone but the view from the sensor is obstructed by another vehicle. This type of occlusion results in the vehicle not being detected by the sensor.

Or

When a vehicle in one lane passes through the detection zone of an adjacent lane. This type of occlusion can result in the same vehicle being counted in more than one lane.

I. Detection Zone. The detection zone is a line or area selected through the VIVDS processor unit that when occupied by a vehicle, sends a vehicle detection to the traffic controller or freeway management system.

J. Detection Accuracy. The measure of the basic operation of a detection system (shows detection when a vehicle is in the detection zone and shows no detection when there is not a vehicle in the detection zone).

K. Live Video. Video being viewed or processed at 30 frames per second.

L. Lux. The measure of light intensity at which a camera may operate. A unit of illumination equal to one lumen per square meter or to the illumination of a surface uniformly one meter distant from a point source of one candle.

M. Video Monitor. As a minimum must be a 9-in. black and white monitor with BNC connectors for video in and out.

3. Functional Capabilities.

The system software must be able to detect either approaching or departing vehicles in multiple traffic lanes. A minimum of 4 detector outputs per video processor module card and each card must have a minimum of 24 detection zones. Each zone and output must be user definable through interactive graphics by placing lines and/or boxes in an image on a video or VGA monitor. The user must be able to redefine previously defined detection zones.

The VIVDS must provide real time vehicle detection (within 112 milliseconds (ms) of vehicle arrival).

The VIVDS processor unit must be capable of simultaneously processing information from various video sources, including CCTV video image sensors and video tape players. The video sources may be, but are not required to be, synchronized or line-locked. The video must be processed at a rate of 30 times per second by the VIVDS processor unit.

The system must be able to detect the presence of vehicles in a minimum of 12 detection zones within the combined field of view of all cameras (a minimum of 12 detection zones per camera input to the VIVDS processor unit).

Detection zones must be provided that are sensitive to the direction of vehicle travel. The direction to be detected by each detection zone must be user programmable.

The VIVDS processor unit must compensate for minor camera movement (up to 2% of the field of view at 400 ft.) without falsely detecting vehicles. The camera movement must be measured on the unprocessed video input to the VIVDS processor unit.

The camera must operate while directly connected to VIVDS Processor Unit.

Once the detector configuration has been downloaded or saved into the VIVDS processor unit, the video detection system must operate with the monitoring equipment (monitor and/or laptop) disconnected or on-line.

When the monitoring equipment is directly connected to the VIVDS processor unit, it must be possible to view vehicle detections in real time as they occur on the field setup computer's color VGA display or the video monitor.

4. Vehicle Detection.

A. Detection Zone Placement. The video detection system must provide flexible detection zone placement anywhere within the combined field of view of the image sensors. Preferred presence detector configurations must be lines or boxes placed across lanes of traffic or lines placed in line with lanes of traffic. A single detector must be able to replace one or more conventional detector loops. Detection zones must be able to be fully overlapped. In addition, detection zones must have the capability of implementing "AND" and "OR" logical functions including presence, extension and delay timing. These logical functions may be excluded if provisions are made to bring each detector separately into the controller and the controller can provide these functions.

B. Detection Zone Programming. Placement of detection zones must be by means of a graphical interface using the video image of the roadway. The monitor must show images of the detection zones superimposed on the video image of traffic while the VIVDS processor is running.

The detection zones must be created by using the mouse or keypad to draw detection zones on the monitor. The detection zones must be capable of being sized, shaped and overlapped to provide optimal road coverage and detection. It must be possible to upload detector configurations to the VIVDS processor unit and to retrieve the detector configuration that is currently running in the VIVDS processor unit.

The mouse or keypad must be used to edit previously defined detector configurations so as to fine tune the detection zone placement size and shape. Once a detection configuration has been created, the system must provide a graphic display of the new configuration on its monitor. While this fine-tuning is being done, the detection must continue to operate from the detector configuration that is currently called.

When a vehicle occupies a detection zone, the detection zone on the live video must indicate the presence of a vehicle, thereby verifying proper operation of the detection system. With the absence of video, the card must have an LED that will indicate proper operation of the detection zones.

Detection zones must be provided that is sensitive to the direction of vehicle travel. The direction to be detected by each detection zone must be user programmable. The vehicle detection zone should not activate if a vehicle traveling any direction other than the one specified for detection occupies the detection zone. Cross-street and wrong way traffic should not cause a detection.

C. Design Field of View. The video detection system must reliably detect vehicle presence in the design field of view. The design field of view must be defined as the sensor view when the image sensor is mounted 24 ft. or higher above the roadway, when the camera is adjacent (within 15 ft.) to the edge of the nearest vehicle travel lane, and when the length of the detection area is not greater than 10 times the mounting height of the image sensor. Within this design field of view, the VIVDS processor unit must be capable of setting up a single detection zone for point detection (equivalent to the operation of a 6 ft. by 6 ft. inductive loop). A single camera, placed at the proper mounting height with the proper lens, must be able to monitor up to and including 5 traffic lanes simultaneously.

D. Detection Performance. Detection accuracy of the video detection system must be comparable to properly operating inductive loops. Detection accuracy must include the presence of any vehicle in the defined detection zone regardless of the lane, which the vehicle is occupying. Occlusion produced by vehicles in the same or adjacent lanes must not be considered a failure of the VIVDS processor unit, but a limitation of the camera placement. Detection accuracy (a minimum of 95%) must be enforced for the entire design field of view on a lane by lane and on a time period basis. When specified in the plans, furnish up to 24 continuous hours of recorded video of all installed intersection cameras within the 30 day test period for verification of proper camera placement, field of view, focus, detection zone placement, processor setup and operation. The video from each camera must show vehicle detections for all zones.

E. Equipment failure, either camera or VIVDS processor unit, must result in constant vehicle detection on affected detection zones.

5. VIVDS Processor Unit.

A. Cabinet Mounting- The VIVDS processor unit must be rack mountable.

B. Environmental Requirements - The VIVDS processor unit must be designed to operate reliably in the adverse environment found in the typical roadside traffic cabinet. It must meet the environmental requirements set forth by the latest NEMA (National Electrical Manufacturers Association) TS1 and TS2 standards as well as the environmental requirements for Type 170, Type 179 and 2070 controllers. Operating temperature must be from -30°F to +165°F at 0% to 95% relative humidity, non condensing.

C. Electrical - The VIVDS must have a modular electrical design.

The VIVDS must operate within a range of 89 to 135 VAC, 60 Hz single phase. Power to the VIVDS must be from the transient protected side of the AC power distribution system in the traffic control cabinet in which the VIVDS is installed.

Serial communications to the field setup computer must be through an RS 232, USB or Ethernet port. This port must be able to download the real time detection information needed to show detector actuations. A connector on the front of the VIVDS processor unit must be used for serial communications.

The unit must be equipped with RS 170 (monochrome) or RS170A (color) composite video inputs video inputs, so that signals from image sensors or other synchronous or asynchronous video sources can be processed in real time. BNC connectors on the front of the VIVDS processor unit or video patch panel must be used for all video inputs.

The unit must be equipped with a single RS 170 composite video output. This output must be capable of corresponding to any one of the video inputs, as selected remotely via the field setup computer or front panel switch. Multiple video outputs requiring external cable connections to create a combined single video output must not be acceptable. A BNC or RCA connector must be used for video output on the front of the processor unit. Any other video formats used must prior approval by TxDOT TRF Signal Operation Engineer.

Software upgrades and/or changes MUST be presented to and approved by TXDOT TRF-TM division, before being used. Failure to do so will be grounds for termination of contract and probation for responsible party(s).

The unit software and the supervisor software must include diagnostic software to allow testing the VIVDS functions. This must include the capability to set and clear individual detector outputs and display the status of inputs to enable setup and troubleshooting in the field.

6. Camera Assembly.

A. Camera. The video detection system must use medium resolution, monochrome image sensors as the video source for real time vehicle detection. The cameras must be approved for use with the VIVDS processor unit by the supplier of the VIVDS. As a minimum, each camera must provide the following capabilities:

1. Images must be produced with a Charge Coupled Device (CCD) sensing element with horizontal resolution of at least 480 lines for black and white or 470 lines for color and vertical resolution of at least 350 lines for black and white or color. Images must be output as a video signal conforming to RS170.

2. Useable video and resolvable features in the video image must be produced when those features have luminance levels as low as 0.1 lux for black and white, and as low as 1.0 lux for color, for night use.

3. Useable video and resolvable features in the video image must be produced when those features have luminance levels as high as 10,000 lux during the day.

4. The camera must include an electronic shutter or auto-iris control based upon average scene luminance and must be equipped with an electronic shutter or auto-iris lens with variable focal length and variable focus that can be adjusted without opening up the camera housing to suit the site geometry. The variable focal length must be adjustable from 6 mm to 34 mm.

B. Camera and Lens Assembly. The camera and lens assembly must be housed in an environmental enclosure that provides the following capabilities:

1. The enclosure must be waterproof and dust tight to the latest NEMA 4 specifications.

2. The enclosure must allow the camera to operate satisfactorily over an ambient temperature range from -30°F to +165°F while exposed to precipitation as well as direct sunlight.

3. The enclosure must allow the camera horizon to be rotated in the field during installation.

4. The enclosure must include a provision at the rear of the enclosure for connection of power and video signal cables fabricated at the factory. Input power to the environmental enclosure must be nominally 115 VAC 60 Hz.

5. A thermostatically controlled heater must be at the front of the enclosure to prevent the formation of ice and condensation, as well as to assure proper operation of the lens's iris mechanism. The heater must not interfere with the operation of the camera electronics, and it must not cause interference with the video signal.

6. The enclosure must be light colored or unfinished and must include a sun shield to minimize solar heating. The front edge of the sunshield must protrude beyond the front edge of the environmental enclosure and must include provision to divert water flow to the sides of the sunshield. The amount of overhang of the sun shield must be adjustable to block the view of the horizon to prevent direct sunlight from entering the lens. Any plastics used in the enclosure must include ultra violet inhibitors.

7. The total weight of the image sensor in the environmental enclosure with sunshield must be less than 10 lb.

8. When operating in the environmental enclosure with power and video signal cables connected, the image sensor must meet FCC class B requirements for electromagnetic interference emissions.

The video output of the cameras must be isolated from earth ground. All video connections for the cameras to the video interface panel must also be isolated from earth ground.

Use waterproof, quick disconnect connectors to the image sensor for both video and power.

A camera interface panel capable of being mounted to sidewalls of a controller cabinet must be provided for protection of the VIVDS processor unit, camera video and power inputs/outputs. The panel must consist of, as a minimum, 4 Edco CX06 coax protectors, a

Edco ACP-340 for the cameras and VIVDS processor unit power, a 10 amp breaker, a convenience outlet protected the ACP-340 and a terminal strip with a minimum of sixteen 8-32 binder head screws. The terminal strip must be protected by a piece of 1/8 in. Plexiglas.

When the connection between the image sensor and the VIVDS processor unit is coaxial cable, the coaxial cable used must be a low loss, 75 ohm, precision video cable suited for outdoor installation, such as Belden 8281 or TxDOT approved equal.

Camera mounting hardware must allow for vertical or horizontal mounting to the camera enclosure. Pelco AS-0166-4-62 or equivalent is acceptable.

7. **Field Communication Link.** The field communications link must be a one way communications connection from the camera to the equipment cabinet. The primary communications link media may be coaxial cable or fiber optic cable accompanied by a 3 conductor minimum 18 AWG, 24 VDC or 115 VAC camera power cable, or appropriate cable as approved.

   The following requirements must govern for the various types of field communications link media described on the plans:

   A. Coaxial Cable. In locations where the plans indicate coaxial cable is required as the primary communications link, this cable must be of the RG 59 type with a nominal impedance of 75 ohms. All cable must have a polyethylene dielectric with copper braid shield having a minimum of 98 percent shield coverage and not greater than 0.78 dB attenuation per 100 ft. at 10 MHz with a minimum 18 AWG external 3 conductor power cable or approved equivalent as directed by the Engineer.

   B. Fiber Optic Cable. If specified by the plans, furnish fiber optic cable in accordance with the special specification for fiber optic cable.

   C. Twisted Wire Pairs. Must be Belden 9556 or equivalent 18 AWG TWP control cable.

   All connection cables must be continuous from the equipment cabinet to the camera. No splices of any type will be permitted.

   Install lightning and transient surge suppression devices on the processor side of the field communications link to protect the peripheral devices. The suppression devices must be all solid state. Lightning protection is not required for fiber optic communication lines. The devices must present high impedance to, and must not interfere with, the communications lines during normal operation. The suppression devices must not allow the peak voltage on any line to exceed 300% of the normal operating peak voltage at any time. The response time of the devices must not exceed 5 nanoseconds.

8. **VIVDS Set-Up System.** The minimum VIVDS set-up system, as needed for detector setup and viewing of vehicle detections, must consist of a field setup computer and Windows based interface software (if required) or a video monitor with interface software built-in to the VIVDS processor unit. Live video (30 frames per second) must be available on the field setup computer to determine proper operation of detectors. The field set-up computer as a minimum, must have an NTSC video input port or equivalent.

If a field setup computer is required for system set-up, it must be supplied by the supplier of the VIVDS.

The field setup computer must include all necessary cabling and a Windows based program to interface with the VIVDS processor unit. This software must provide an easy to use graphical user interface and support all models/versions of the supplied VIVDS.

Live video with the detection overlaid is required for field verification of the system.

9. **Temporary Use and Retesting.**

   A. Temporary Use. When shown on the plans, the VIVDS equipment must be used to provide vehicle detection on a temporary basis. When the permanent vehicle detection system and related equipment are installed and made operational, the VIVDS equipment must be carefully removed and delivered to the location shown on the plans.

   B. State Retesting and Acceptance. Prior to acceptance, all VIVDS equipment may be retested by the State, even if the system was operating properly before removal. Repair or replace any equipment damaged during removal or transport and any equipment that does not meet the various test requirements.

10. **Operation from Central Control.** The central control must transmit and receive all information needed for detector setup, monitor the vehicle detection, view the vehicle traffic flow at a rate of 2 frames per second or greater for telephone, or 5 frames a second or greater for ISDN lines (as specified by the plans), and interrogate all required stored data. The remote communications link between the VIVDS processor unit and central control may be dial-up (telephone or ISDN lines) or dedicated twisted wire pair communications cable which may be accompanied with coaxial cable or fiber-optic cable, as shown on the plans. Communications with the central control must not interfere with the on-street detection of the VIVDS processor. Quality of the video at 2 frames per second rate must be such that the view with the traffic flow is clear and in focus.

11. **Installation and Training.** The supplier of the video detection system must supervise the installation and testing of the video and computer equipment. A factory certified representative from the supplier must be on site during installation.

    In the event that the field setup computer is furnished by TxDOT, such installation and testing must be done at the time that training is conducted.

    Provide up to 2 days of training to personnel of TxDOT in the operation, setup and maintenance of the video detection system. Provide instruction and materials for a maximum of 20 persons and conduct at a location selected by TxDOT. TxDOT will be responsible for any travel and room and board expenses for its own personnel.

    Instruction personnel are required to be certified by the equipment manufacturer. The User's Guide is not an adequate substitute for practical, classroom training and formal certification by an approved agency.

    Formal levels of factory authorized training are required for installers, contractors and system operators. All training must be certified by the manufacturer.

12. **Warranty, Maintenance and Support.** The video detection system must be warranted to be free of defects in material and workmanship for a period of 5 years from date of shipment from the supplier's facility. During the warranty period, the supplier must repair with new or refurbished materials, or replace at no charge, any product containing a warranty defect provided the product is returned FOB to the supplier's factory or authorized repair site. Return product repair or replaced under warranty by the supplier with transportation prepaid. This warranty does not apply to products damaged by accident, improperly operated, abused, serviced by unauthorized personnel or unauthorized modification.

    During the warranty period, technical support must be available from the supplier via telephone within 4 hours of the time a call is made by a user, and this support must be available from factory certified personnel or factory certified installers.

    Ongoing software support by the supplier must include updates of the VIVDS processor unit and supervisor software (if a field setup computer is required for set up). Provide these updates free of charge during the warranty period. The update of the VIVDS software to be NTCIP compliant must be included.

    The supplier must maintain a program for technical support and software updates following expiration of the warranty period. Make this program available to TxDOT in the form of a separate agreement for continuing support.

    The supplier must maintain an ongoing program of technical support for the wireless camera system. This technical support must be available via telephone or personnel sent to the installation site.

    The supplier must maintain an adequate inventory of parts to support maintenance and repair of the camera system.

13. **Measurement.** The VIVDS will be measured as each major system component furnished, installed, made fully operational, and tested in accordance with this special specification or as directed by the Engineer.

    The VIVDS communication cable will be measured by the linear foot of the appropriate media type furnished, installed, made fully operational, and tested in accordance with this specification, other referenced Special Specifications or as directed by the Engineer.

    When the VIVDS is used on a temporary basis, the VIVDS must be measured as each system furnished, installed, made fully operational, including reconfiguration and removal if required by the plans, and tested in accordance with this special specification or as directed by the Engineer.

    This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2, "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

    When recorded video is required by the plans it will be paid for by each camera recorded.

14. **Payment**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "VIVDS Processor System", "VIVDS Camera Assembly", "VIVDS Central Control",

"VIVDS Set-up System", "VIVDS Temporary", "VIVDS Communication Cable (Coaxial)," "VIVDS Communication Cable (Fiber Optic)", "VIVDS Video Recording", and all accompanying software. These prices are full compensation for furnishing, placing, and testing all materials and equipment, and for all tools, labor, equipment, hardware, operational software package(s), supplies, support, personnel training, shop drawings, documentation, and incidentals. A 3-conductor power cable must be included with the communication cable.

These prices also include any and all interfaces required for the field and remote communications links along with any associated peripheral equipment, including cables; all associated mounting hardware and associated field equipment; required for a complete and fully functional visual image vehicle detection system component.

B/CS UNIFIED
SPECIFICATION NO. 150

CONCRETE

(Sentences and/or paragraphs that are double underlined indicate revisions that were made from the 2006 specification.)

150.01 DESCRIPTION

This specification shall govern for Portland cement concrete to be used in concrete pavement, concrete structures and other concrete construction.

150.02 MATERIALS

A. PORTLAND CEMENT:

Cement shall be Type I, II or III Portland Cement conforming to ASTM C150, or Type IA, IIA or IIIA, conforming to ASTM C175 except as noted below.

1. Different types of cement, as prescribed above may be used in the same structure, but all cement used in any one monolithic placement shall be of the same type and brand.

2. Type III cement shall not be used when the anticipated air temperature for the succeeding 12 hours will exceed 60 °F.

B. FLY ASH:

Fly Ash shall be Type C or F Fly Ash in accordance with ASTM C618. When fly ash is used, "cement" shall be defined as "cement plus fly ash". "Cement plus fly ash" shall be composed of Type I, II or III Portland cement and 20 to 35 percent fly ash by absolute volume, except that for classes of concrete which are specified to have less than five (5) sacks of Portland cement per cubic yard, the fly ash replacement of cement shall not exceed 25 percent by absolute volume of the specified cement content.

C. AGGREGATE:

1. Concrete aggregate shall conform to all requirements of Texas Department of Transportation Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges (2004) Section 421.2 E 1, 2 and 3, and ASTM C33.

2. The maximum size of aggregate shall not be larger than one-fifth of the narrowest dimension between forms of the member for which concrete is to be used nor larger than three-fourths of the minimum clear spacing between reinforcing bars.

D. WATER:

Water for use in concrete and for curing shall be from municipal supplies approved by the Texas Commission on Environmental Quality and Texas Department of Health or shall conform to the provisions of AASHTO T26 for quality of water.

E. REINFORCING STEEL:

1. The reinforcing steel shall be Grade 60.

2. Steel reinforcing bars as required, shall be of the type and size as shown on Plans and shall be open hearth new billet steel of structural, intermediate, or hard grade, or shall be rail steel concrete reinforcement bars. All steel shall be bent cold.

3. New billet steel shall conform to the requirements of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars, ASTM Designation A-15.

4. When fabricated steel bar or rod mats are specified, the mats shall meet the current requirements of specifications for Fabricated Steel Bar or Rod Mats for Concrete Reinforcement ASTM Designation A-184.

5. In the event reinforcing bars manufactured outside of the Continental United States or its territories are used, two sets of tests from an independent testing laboratory acceptable to the Engineer shall be submitted showing that the steel meets the ASTM Standards for tensile strength, phosphorus content, bend, deformations and such other requirements outlined in the ASTM Standards for the grade used. These tests shall be made by and independent testing laboratory at the Contractor's expense and shall be submitted for each 25 tons of steel supplied from each individual mill.

6. At the time of placement in the concrete, reinforcing steel shall be free of dirt, loose rust, mill scale, paint, grease, oil or other deleterious materials that would impair the bonding of the concrete to the steel.

7. Reinforcement shall be accurately positioned and, unless otherwise shown or specified, shall be secured against displacement by using at intersection, annealed iron wire of not less than No. 18 gauge or suitable metal clips. It shall be supported by plastic or metal chairs or spacers. In general, reinforcement shall be placed, spliced, lapped, located, etc., in accordance with the recommendations of the Concrete Reinforcement Steel Institute or Texas Department of Transportation Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges (2004) Section 440.

8. Under no circumstances shall reinforcing steel or dowel bars be "stabbed" into fresh concrete. When reinforcing steel or dowel bars are required to extend beyond the slip-formed surface, holes shall be drilled and the steel shall be epoxyed into place using a pre-approved epoxy.

F. STORAGE OF MATERIALS:

1. All cement, fly ash and mineral filler shall be stored in well-ventilated weatherproof buildings or pre-approved bins, which will protect them from dampness or absorption of moisture.

2. The method of handling and storing concrete aggregates shall prevent contamination with foreign materials. To assure uniform concrete, aggregate stockpiles shall be maintained at reasonably uniform moisture content.

150.03 SUBMITTALS

List of Admixtures proposed
Concrete Mix Designs and three sets of tests on the mix designs submitted.
Certification for cement conformance to specification
Test reports for all required concrete tests
Mill report/Certifications for all Reinforcing Bar.
Material Data on Control, Expansion and Contraction Joint materials and sealants.

150.04 CONSTRUCTION METHODS

150.04.1 PREPARATION OF EQUIPMENT AND PLACE OF DEPOSIT:

1. Before placing concrete, all equipment for mixing and transporting the concrete shall be cleaned. All debris shall be removed from the place to be occupied by the concrete.
2. Water shall be removed from place of deposit before concrete is placed unless otherwise permitted by the Engineer.

150.04.2 MIXING OF CONCRETE

1. The concrete shall be mixed until there is a uniform distribution of materials and shall be discharged completely, before the mixer is recharged.
2. For job-mixed concrete, the mixer shall be rotated at a speed recommended by the manufacturer. Mixing shall be continued at least one (1) minute after all materials are in the mixer. Job-mixed concrete shall be rejected and disposed of as directed if not placed as prescribed within thirty (30) minutes after beginning of mixing. Job-mixed concrete is only allowed with written approval from the City Engineer 72-hours prior to the pour.
3. Ready-mixed concrete shall be measured, mixed and delivered in accordance with the requirements set forth in "Standard Specifications for Ready-Mixed Concrete" (ASTM C-94).

150.04.3 CONVEYING

1. Concrete shall be conveyed from the mixer to the place of final deposit by methods which will prevent the separation or loss of the materials.
2. Equipment for chuting, pumping, and pneumatically conveying concrete shall be of a size and design to insure a continuous flow of the concrete at the delivery point, without separation of the materials.

150.04.4 TRANSPORTATION EQUIPMENT

Transportation of concrete mixed completely in a stationary mixer, from the mixer to the point of placement, shall be by truck agitator, or in a truck mixer operating at agitator speed, or in non-agitating equipment conforming to ASTM Standard C-94 except as modified herein. Truck agitators, truck mixers, and non-agitating equipment shall be capable of delivering concrete without segregation in transit. Slump tests of individual samples taken at approximately the one-quarter and three-quarter points of the load during discharge shall not

vary by more than 1 inch. Vehicles transporting concrete mixed partially or completely in stationary mixers shall be equipped with discharge chutes or other devices when operating outside of the prepared subgrade, or shall be supplemented by additional transfer equipment capable of discharging or transferring the concrete from the transporting vehicle to its final position in the form without segregation.

150.04.5 FACILITIES FOR SAMPLING

Suitable facilities shall be provided for readily obtaining representative samples of aggregate from each of the bins or compartments for test purposes. Suitable facilities shall be provided for obtaining representative samples of concrete for uniformity tests. All necessary platforms, tools, and equipment for obtaining samples shall be furnished by the Contractor.

150.04.6 PLACING CONCRETE

1. The Contractor shall give the Engineer a minimum 24 hours advance notice before placing concrete to permit the inspection of forms, reinforcing steel placement and other preparations.
2. Concrete placement will not be permitted when impending weather conditions would impair the quality of the finished work.
3. Transporting Time: The maximum time interval between the addition of cement to the batch and the placing of concrete in the forms shall conform to the requirements below:

Concrete Temp (at point of placement)	Max Time (No Retarding Agent Minutes)	Max Time (with Retarding Agent) Minutes
Non-Agitated Concrete		
Above 80 F	15	30
80 F and Below	30	45
Agitated Concrete		
Above 90 F	45	75
Above 75 F thru 90 F	60	90
75 F and Below	90	120

4. All forms, sub grade and steel shall be dampened before placement of concrete to assist with retaining moisture in the concrete.

5. Cold Weather Precautions:

   Concrete shall not be placed when the ambient temperature is below 40 °F and falling. Concrete may be placed when the ambient temperature is above 35 °F and rising, the ambient temperature being taken in the shade and away from artificial heat. Concrete shall not be placed when the forecast predicts 72 continuous hours of temperatures less than 32 °F.

   The Contractor shall have available a sufficient supply of pre-approved cotton mats, polyethylene sheeting or other pre-approved covering materials to immediately protect concrete if the air temperature falls to 32 °F, or below, before concrete has been in place for less than four (4) hours. Such protection shall remain in place during the period the temperature continues below 32 °F, or for a period of not more than five (5) days.

Neither salt nor other chemical admixtures shall be added to the concrete to prevent freezing. The Contractor shall be responsible for the quality and strength of concrete under cold weather conditions and any concrete damaged by freezing shall be removed and replaced at the Contractor's expense.

The surface of all concrete in bents, piers, culvert walls, retaining walls, bottom of slabs, and similar formed concrete shall be maintained at 40 °F or above for a period of 72 hours from the time of placements. The temperature of all concrete, including the bottom slabs (footings) of culverts placed on or in the ground, shall be maintained above 32 °F for a period of 72 hours from time of placement.

Protection shall consist of providing additional covering, insulated forms or other means, and if necessary, supplementing such coverings with artificial heating.

6. Warm Weather Precautions

   The following precautions shall be taken in placing, curing, and protecting the concrete when local weather records show that the maximum daily temperature is likely to exceed 95 °F. The forms and the subgrade, subbase or base course shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete exceed 95 °F when deposited on the subgrade, subbase or base course. The temperature of the concrete shall not exceed 85 °F for bridge slabs or in the top slab of direct-traffic culverts. The aggregates and/or mixing water will be cooled as necessary to maintain the concrete temperature within the specified maximum. Concrete shall be placed in the forms continuously and rapidly at a rate of not less than 100 feet of paving lane per hour. The surface of the newly laid pavement shall be kept damp by means of a water fog or mist applied with pre-approved spraying equipment until the pavement is covered by the pre-approved curing medium.

7. Concrete shall be deposited as nearly as practicable in its final position to avoid segregation due to rehandling or flowing. The deposition shall be at a rate that allows the concrete to be plastic at all times and permits flow readily into the space between the rebar. Retempered concrete shall not be used and concrete shall not have a free fall of more than five (5) feet, except in the case of thin walls such as in culverts or as specified in other items. Any hardened concrete spatter ahead of the plastic concrete shall be removed.

8. Concrete deposition shall be a continuous operation until completed at the panel or section. Cold joints in a monolithic placement shall be avoided. The sequence of successive layers or adjacent portions of concrete shall be such that they can be vibrated into a homogeneous mass with the previously placed concrete. Not more than one (1) hour shall elapse between adjacent or successive placements of concrete.

9. Concrete shall be thoroughly consolidated and vibrated in the forms with pre-approved mechanical vibrators of a type considered in the design of forms.

150.04.07 FINISHING

Unless noted otherwise, apply an ordinary surface finish as the final finish to the following exposed surfaces:

- inside and top of inlets,
- inside and top of manholes,

- inside of sewer appurtenances,
- inside of culvert barrels, bottom of bridge slabs between girders and beams, and
- vertical and bottom surfaces of interior concrete beams or girders.

An ordinary surface finish shall be as follows:

- Chip away all loose or broken material to sound concrete where porous, spalled, or honeycombed areas are visible after form removal.
- Repair spalls by saw-cutting and chipping at least 1/2 in. deep, perpendicular to the surface to eliminate feather edges. Repair shallow cavities using a latex adhesive grout, cement mortar, or epoxy mortar as pre-approved. Repair large areas using concrete as directed or pre-approved.
- Clean and fill holes or spalls caused by the removal of form ties, etc., with latex grout, cement grout, or epoxy grout as pre-approved. Fill only the holes. Do not blend the patch with the surrounding concrete. On surfaces to receive a rub finish in accordance with Item 427, "Surface Finishes for Concrete," chip out exposed parts of metals chairs to a depth of 1/2 in. and repair the surface.
- Remove all fins, runs, drips, or mortar from surfaces that will be exposed. Smooth all form marks and chamfer edges by grinding or dry-rubbing.
- Ensure that all repairs are dense, well bonded, and properly cured. Finish exposed large repairs to blend with the surrounding concrete where a higher class of finish is not specified.

Finish of Bridge Slabs and related features shall be in compliance with TxDOT Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges (2004) Section 420.4.

150.04.8 CURING

The concrete shall be kept wet by spraying with water after attaining its final set and before removing the forms. Bottom forms supporting floor or roof slabs shall remain in place for not less than seven (7) days. The concrete shall have attained a compressive strength of not less than 2,000 psi prior to removal of bottom forms. All other forms may be removed twenty-four hours after completion of concrete placement, providing the weather has allowed the concrete to attain its final set in less than five (5) hours. The forms shall be left on for forty-eight (48) hours whenever the temperature of the air in the shade during pouring is 90 °F or over. Curing shall be continued for five days after placement of concrete. This may be done with wet mats, with two applications of Type I (White in color) Liquid-Membrane-Forming Compound meeting requirements of ASTM C309, or with waterproof curing paper meeting the requirements of ASTM C171.

150.04.9 CONSTRUCTION JOINTS

Construction joints will be made only at locations shown on the Plans unless written permission is granted by the Engineer to make additional joints. Unless otherwise required, make construction joints square and normal to the forms. Use bulkheads in the forms for all vertical joints. Thoroughly roughen the top surface of a concrete placement terminating at a horizontal construction joint as soon as practical after initial set is attained. Thoroughly clean the hardened concrete surface of all loose material, laitance, dirt, and foreign matter. The surface is to be dampened just prior to casting of concrete against the joint.

150.05 TESTING REQUIREMENTS

150.05.1 CONCRETE QUALITY AND ALLOWABLE STRESSES

CONCRETE QUALITY:

Concrete mixes will be designed and made in sufficient number to represent the required water-cement ratios. These mixes shall comply with the requirements prescribed for strength and consistency as shown below. The Contractor shall furnish the results on trial mixes from a testing laboratory pre-approved by the Engineer.

Minimum Compressive Strength, psi at 28 days	Minimum Cement Content Sack/cubic yard	Maximum Water Content Gal/sack of cement	General Usage
1,500	3.0	11.0	Riprap
3,000	4.5	6.0	Drilled Shaft, Inlets; Manholes; Headwalls; Sidewalks; Driveways;
3,500	5.0	6.0	Concrete Pavement; curb and gutters
4,000	5.5	5.0	Bridge slab; Culverts

The slump of concrete mixtures shall be within the following limits when measured according to "Test for Slump of Portland Cement Concrete" (ASTM C142). When admixtures are used to increase the workability, the mix design shall indicate the slump before and after its introduction into the mix.

TYPE OF CONSTRUCTION	**COMPRESSIVE STRENGTH OF CONCRETE, psi**	**MAXIMUM SLUMP (before admixtures)**
Concrete Pavement	3,500	3"
Curb and Gutter	3,500	3"
Sidewalk	3,000	5"
Drilled Shafts and Footings	3,000	7"
Thin Walled Sections (9" or less)	3,000	5"
Thick Walls	By Special Design	

150.05.2 TESTS ON CONCRETE

1. During the progress of the work, compression test specimens shall be made and cured in accordance with "Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field" (ASTM C31). Not less than three specimens shall be made for each test, nor less than one test for each 50 cubic yards or fraction thereof of concrete placed or for each days pour. These tests shall be made by an independent testing laboratory at the Owner's expense.

2. Specimens shall be tested in accordance with "Standard Method of Test for Compressive Strength of Molded Concrete Cylinders" (ASTM C39).

3. The standard age of test shall be 7 days and 28 days.

4. If the average strength of the control cylinders for any portion of the structure falls below the specified compressive strength, the Engineer shall have the right to order changes in the proportions or the cement content for the remaining portion of the structure. If the concrete minimum 28 day strength is not achieved the Engineer shall have the right to order its removal.

5. An air-entraining admixture may be used with Type I, II, or III Portland Cement in lieu of an Air-Entraining Portland Cement. The admixture shall meet the requirements of "Specifications for Air-Entraining Admixtures for Concrete" (ASTM C260). Concrete produced from either Type IA, IIA, or IIIA cement or the use of air-entraining admixtures shall have an air content from 3 to 5 percent when determined by means of the test for air-content, ASTM C231.

150.05.3 TEST CYLINDERS

Preparation of test cylinders and tests on concrete cylinders shall be made at the expense of the Owner. The cost of all failed tests shall be charged to the Contractor.

150.06 MEASUREMENT

In general and unless otherwise specified, no separate payment will be made for concrete as an item. The cost of concrete including all materials and equipment, furnishing and placing all reinforcing steel, and performing all labor for the manufacturing, transporting, placing, finishing, and curing of concrete will be included in the unit price bid for specific items as set forth in the Proposal. Payment will not be made for unauthorized work.