DIVISION 700
TRAFFIC CONTROL FACILITIES

SECTION 701
ACTUATED CONTROLLER

701.01 Description. This item shall consist of furnishing and installing an actuated controller and other associated equipment according to these specifications and at the locations shown on the plans or as directed.

701.02 Materials. (a) General. The controller, cabinet, and all accessories in the cabinet shall be furnished by one supplier. All controllers on a project shall be made by one manufacturer, shall be menu driven, and shall comply with the latest NEMA TS 1 or TS 2–Type 2 specifications as specified in the Contract Summary of Quantities. The supplier shall test the controller and all accessories in the cabinet as a unit before shipment to the Contractor.

The Contractor shall submit to the Engineer for approval two copies of the applicable brochures containing design criteria for the components. The specific items proposed for use shall be clearly marked in the brochures. If more than one item is submitted at one time for Department review, a list shall be attached showing each item for which Department approval of design characteristics is being requested. The Engineer will provide written approval of the design characteristics.

(b) Controller Design Requirements.

(1) Consistency of Intervals. The length of any interval, position, period, or unit extension shall not change by more than 5% of its value if the voltage of the power supply varies between the limits of 95 to 135 volts.

(2) Power. The controller and associated equipment shall be designed for use on 120 volt, 60 Hz alternating current.

(3) Mechanism. The timing circuits shall consist entirely of solid state electronic circuitry. No vacuum or gaseous tubes shall be used in any timing circuits.

Switching functions shall be accomplished by solid state electronic circuitry. No electromechanical devices such as

camshafts and rotary, stepping, or line switches shall be used for switching functions.

Functional operating circuits and their associated components shall be grouped in plug-in, printed circuit assemblies. Similar assemblies shall be interchangeable between controllers.

The components shall be amply de-rated regarding heat-dissipating capacity and rated voltage so that, with maximum ambient temperature and maximum applied voltage, material shortening of life or shift in values shall not occur.

(4) Interval Sequence. The controller shall provide and be set up for the proper intervals and interval sequence as provided on the plans.

(5) Interval Setting and Adjustment. The controller shall provide for the setting up of each interval or period by means of thumbwheel dials, pins, or keyboard entry. There shall be, at a minimum, the following settings for each phase:

- Initial
- Extension (gap)
- Maximum (maximum green or extension limit)
- Yellow Change
- Red Clearance
- Walk
- Pedestrian Clearance

The settings shall be calibrated in seconds and shall give a clear visual indication of the length of each interval or period. The timing setting devices and setting displays shall be on the front of the controller and easily identifiable. It shall not be necessary to remove or change wires or contacts or to use any tools in making interval adjustments.

Indications shall be provided for at least the following functions, but not limited thereto:

- Phase or phases in service.
- Phase or phases next to be serviced.
- Presence of vehicle call, including memory and detector actuation.
- Presence of a pedestrian call.
- The interval(s) timing and controller conditions.

(6) Pedestrian Interval. Unless otherwise noted, pedestrian intervals shall be push button actuated and concurrently timed with the associated phase.

(c) Cabinet.

(1) General. The controller shall be furnished completely housed in an aluminum alloy or stainless steel cabinet. The cabinet shall be of clean-cut design and appearance. The size of the cabinet shall be such as to provide ample space for housing the controller and associated electrical devices that are to be furnished with it, together with other auxiliary devices herein specified. A hinged door shall be provided, permitting complete access to the interior of the cabinet. When closed, the door shall fit closely to gasket materials, making the cabinet weather-resisting and dust tight. The door hinges and pins shall be of non-corroding material. The cabinet shall be equipped with an interior fluorescent light that switches on automatically when the cabinet door is opened.

The cabinet shall contain a mounting table, sliding ways, or other suitable support for the controller.

Cabinets shall not be painted unless otherwise specified.

Minimum cabinet size – The cabinet shall be large enough to allow trouble shooting of all terminal facilities while the intersection is in operation without removing any equipment from the cabinet. Stacking equipment or mounting active equipment (detectors, radios, conflict monitor, etc.) on the door is not permitted. Cabinet size shall be based as a minimum upon the number of phases specified in the unit item table shown below. In addition minimum cabinet volume and the minimum number of load sockets shall be equal to or greater than the following:

Table of Minimum Cabinet Requirements*

No. Phases	Class	Det. Inps.	Load Sockets			Depth inches (mm)	Width inches (mm)	Height inches (mm)
			Phase (N)	OL	Ped			
2	G	4	2		2	16″ (400)	25″ (630)	41″ (1040)
3	M	8	3	3**	2	17″ (430)	30″ (760)	49″ (1240)
4	M-36	8	4	2**	2	17″ (430)	36″ (910)	49″ (1240)
5	M-36	16	5	4**	3	17″ (430)	36″ (910)	49″ (1240)
6	P-38	24	6	2**	4	26″ (660)	38″ (960)	55″ (1400)
7	P-38	24	7	1**	4	26″ (660)	38″ (960)	55″ (1400)
8	P-38	24	8		4	26″ (660)	38″ (960)	55″ (1400)
>8 or "spec."	R-44	24	12	12-N ***	4	26″ (660)	44″ (1120)	77″ (1960)

* Where additional Pedestrian phases are required, Overlap (OL) sockets may be utilized for Pedestrian Signal outputs unless required as part of the specified phasing. Intersections with overlaps, more than 2 rings, or other than standard quad left phasing may require additional load sockets. Addition of other auxiliary equipment may require the use of a larger cabinet.

**Detector inputs (Det. Inps.) are total including Pedestrian.

***Where designated as "Special" (spec.) phasing, N refers to number of phases.

(2) Locks. The main cabinet door shall have a tumbler lock keyed for a Corbin No. 2 key. The auxiliary door shall be equipped with a lock for a standard police key. When the door is closed and latched, with the key removed, the door shall lock. The Contractor shall furnish two keys for each lock to the City or County.

(3) Door Stop. The cabinet shall be equipped with a door stop assembly.

(4) Mounting. The cabinet shall be furnished with all the necessary mounting hardware for field mounting of the cabinet as specified or as shown on the plans.

(5) Fan and Ventilation. Each cabinet shall be provided with louvered vents and a permanent, washable, removable electrostatic filter with an aluminum frame, mounted in the front door. The filter shall meet the "American Society of Heating, Refrigeration, and Air Conditioning Engineers" (ASHRAE) testing requirements as follows:

Arrestance	90%
Dust Holding Capacity	85 grams at 0.5 water gauge

The cabinet shall also be equipped with an electric fan assembly with a minimum capacity of 100 cubic feet per minute (2.8 cubic meters per minute).

The fan shall be mounted in the top of the cabinet in a manner to prevent rain from entering the cabinet. The fan shall be thermostatically controlled and shall be manually adjustable to turn on between 90° F (32° C) and 150° F (66° C).

(6) Grounding. A copper equipment grounding buss shall be provided in each cabinet. The ground buss shall be grounded to the cabinet and shall provide at least 14 terminals. The ground side of the power supply shall be bonded directly to a ground rod in the cabinet or pole base with a #8 AWG solid copper wire. The wire path shall be as direct as possible and the wire shall contain no splices. The ground rod shall be as shown on the plans or as directed by the Engineer. The cabinet ground wire shall be connected to the ground rod by means of an approved thermal fusion type weld.

(7) Wiring. Panel wiring shall be neat and firm, and the panel shall mount at least:

- Terminal for power supply line.
- Terminal for neutral side of power supply line.
- Terminals for conductors of traffic signal cable: one for each signal circuit and one or more terminals for the common conductors.

The controller equipment and terminals shall be so arranged within the cabinet that they will not interfere with the entrance and connection of the incoming conductors.

All terminals shall be suitably identified and shall be permanently associated with the terminal block. Not more than 3 conductors shall be brought to any 1 terminal screw. No electrically alive parts shall extend beyond the protection afforded by the barrier.

Electrical connections from the controller to the outgoing and incoming circuits shall be made by inserting a multi-terminal plug (Type MS) into the plug receptacle incorporated in the controller. The controller shall be replaceable with a similar unit without the necessity of disconnecting and reconnecting the individual wires leading therefrom.

The controller cabinet shall be wired such that during flash operation, power to the load switches cannot back-feed to the load switch power buss.

(8) Surge Protection. The cabinet AC service must be provided with a series hybrid type protector (EDCO Model SHA-1250 or equal) with the following terminals:

- Main Line (AC line first stage terminal).
- Main Neutral (AC Neutral input terminal).
- Equipment Line In (AC line second stage input terminal, 10 amps).
- Equipment Neutral Out (Neutral terminal to protected equipment).
- Ground (Earth connection).

Each messenger wire of interconnect cable shall also be provided with a series hybrid type surge protector connected between the interconnected line and the AC return.

Each loop detector input circuit (at cabinet entry point) shall be provided with a series hybrid type surge protector capable of protecting the detector against differential surges between the loop leads and common mode surges between leads and ground.

Each solid state load switch shall be provided with a series hybrid type surge protector capable of protecting the load switch against common mode surges.

(d) Cabinet Auxiliary Equipment.

(1) Conflict Monitor. The conflict monitor shall be a solid state device capable of detecting conflicting signal displays and/or improper power supply voltage from the controller. The conflict monitor shall comply with the latest NEMA TS 1 or TS 2-Type 2 specifications for MMU operation according to the type of controller specified in the Summary of Quantities. All conflict monitors on a project must be made by one manufacturer.

When TS 2-Type 2 is required, in addition to the standard features required by TS 2 specifications, error sensing of 24 vdc cabinet supplies and controller power supplies shall also be provided. The conflict monitor shall communicate through or to the local controller for logging event monitoring. The monitor shall record in non-volatile memory, a minimum of 100 events with time/date and nature of event. The unit shall interface to a standard PC through an RS232 port. The agency maintaining the equipment and the Engineer shall each be provided with one copy of the software.

(2) Solid State Load Switch. The solid state load switches shall be used for opening and closing traffic signal circuits. The assemblies shall be external to the controller and shall be jack mounted. The load switches shall comply with the latest NEMA specifications. The cabinet shall be furnished with load switch sockets wired to provide all necessary signal output circuits plus any future expansion noted on the plans. There shall be at least one pedestrian load switch socket provided for each vehicle through phase.

(3) Solid State Flasher. The cabinet shall be furnished with a two-circuit solid state flasher. It shall be used for the alternate opening and closing connections between the applied power and the signal lamps required for flashing operations. The unit shall commence flashing operation when AC power is applied to the input terminals. It shall provide 50 to 60 flashes per minute on each output circuit and have equal on and off time. The flasher shall comply with the latest NEMA specifications.

(4) Flash Transfer Relays. Electromechanical or solid state relays may be used for opening and closing traffic signal field circuits.

Relays used for this purpose shall be covered, insulated, or located so that electrically alive parts are not readily exposed.

(5) Flash Sequence Programming. A programming means shall be provided to alter whether flashing yellow or red appears on the output field terminals to the signal heads. Programming may be accomplished with tools such as a screwdriver and wrench.

(6) Harness Wiring. All cabinet wiring harnesses shall be neat, firm, and routed to minimize crosstalk and electrical interference. Printed circuit mother boards may be used to reduce cabinet wiring.

Wiring containing AC shall be routed and bundled separately by function, or shielded separately by function, from all low voltage control circuits. All conductors and live terminals or parts that could be hazardous to maintenance personnel shall be covered with suitable insulating materials.

All vehicle detectors shall input the controller separately unless otherwise noted on the plan sheets. Controller and cabinet shall be wired to terminal facilities for the minimum number of detector inputs as indicated on the table "Minimum Cabinet Requirements" above, including Pedestrian Push Buttons. Odd numbered Pedestrian Inputs may be shared as vehicle detector inputs unless utilized in the intersection operation. Controller shall be factory programmed to actuate the appropriate phase as shown on the plan sheets. A chart or table of detector number (as indicated on the plan sheet(s)) to controller input shall be provided to the Engineer prior to requesting time settings and placing the intersection into operation. All wiring harnesses required for expansion to the full capabilities of the controller for the number of phases specified in the unit item table shall be installed. A minimum of one single channel detector harness or detector rack position (whichever shall apply) for each phase shall be installed with a minimum of one wired in place on each NEMA input. Terminal facilities as well as lightning suppression shall also be installed for each detector harness.

Optical isolators with a visual indication of an incoming call shall be provided for all external input devices, including Pedestrian Push Buttons. Auxiliary Isolator/Indicators are not required on devices located within the controller cabinet that have self-contained isolators and indicators on the front panel.

(7) Power Panel. The cabinet shall have a power distribution panel containing a 50 amp radio interference suppressor, a 30 amp main circuit breaker, and a 15 amp auxiliary equipment circuit breaker.

(8) Police Panel. The main door of the cabinet shall have a small police panel door. Behind this door shall be a panel with a signal flash switch and a manual control switch and cord.

In the flash position, the signals flash switch shall cause the intersection to be placed in flashing operation. Stop time shall not be applied to the controller in the manual flash position.

(9) Maintenance Panel. There shall be a maintenance panel on the inside of the main door containing the following:

- Convenience outlet with GFI protection. (Note: The outlet may be mounted on the door panel or inside the cabinet).
- Signals switch.
- Controller switch.
- Detector Test Switches

Detector test switches shall be wired to each controller input required for vehicle detectors and pedestrian push switches. Test switches shall consist of momentary, normally open, push switches.

Separate non-GFI protected duplex receptacle(s) shall be provided for power supplies or other auxiliary equipment which must connect to 120 VAC line voltage. This is in addition to the GFI provided receptacle provided above.

(10) Wiring Diagrams and Controller Manual. Three copies of the cabinet wiring diagram and one copy of the controller manual shall be supplied with each cabinet. One diagram and the manual shall be placed in a heavy duty clear plastic pouch and attached to the cabinet door. This pouch shall be of such design and material that it provides adequate storage and access to the wiring diagram and manual. One diagram shall

be delivered to the City or County before final inspection of the intersection. One diagram shall be given to the Engineer.

(11) Time of Day Clock. All controllers shall have internal time of day programming with an internal time clock.

(e) Certification. The supplier shall provide to the Contractor a certification of compliance with the above requirements and that the controller and conflict monitor comply with the latest NEMA specifications. This certification shall be transferred to the Department.

(f) Mounting Pad. When required, the mounting pad shall be constructed as shown on the plans or as directed by the Engineer.

701.03 Construction Requirements. The controller shall be mounted as shown on the plans or as directed and shall in no case be located less than 3' (1 m) from the pavement edge.

The Contractor shall furnish and properly install each cabinet and controller with accessory equipment and perform the necessary splicing and connections, testing of circuits, adjustments, and such other operations as may be necessary to ensure that each complete traffic signal installation, with all of its components, be completely integrated and tested as a unit so that the desired control of the intersection is attained, complete, and in the best of working order, to the satisfaction of the Engineer. The Contractor shall meet with the City or County and provide them with instructions on the adjustments of the controller and provide consultation for replacement parts stocking.

701.04 Method of Measurement. Actuated Controllers will be measured by the unit. One unit shall include the controller; the controller cabinet; the pad on which the cabinet is installed, when required; and all hardware required for installing the cabinet.

701.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Actuated Controller of the phases and the NEMA TS type specified, which price shall be full compensation for furnishing the Actuated Controller and mounting the controller cabinet; for installing, wiring and testing the controller; for excavation and backfilling; for construction of the mounting pad;

and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Actuated Controller TS 1 (___Phases)	Each
Actuated Controller TS 2-Type 2 (___Phases)	Each

SECTION 702
PRE-TIMED CONTROLLER

702.01 Description. This item shall consist of furnishing and installing pre-timed, solid state, digital timed, multidial traffic signal controllers according to these specifications and at the locations shown on the plans or as directed.

702.02 Materials. (a) General. The controller, cabinet, and all accessories in the cabinet shall be supplied to the Contractor by one supplier and shall comply with the latest NEMA specifications. All controllers on a project must be made by one manufacturer. The supplier must test the controller and all accessories in the cabinet as a unit before shipment to the Contractor.

The Contractor shall submit to the Engineer for approval two copies of the applicable brochures containing design criteria for the components. The specific items proposed for use shall be clearly marked in the brochures. If more than one item is submitted at one time for Department review, a list shall be attached showing each item for which Department approval of design characteristics is being requested. The Engineer will provide written approval of the design characteristics.

(b) Controller Design Requirements.

(1) Functional Requirements. The controller shall be designed to operate as a pre-timed isolated intersection controller or an interconnected multidial controller.

The controller operation shall be completely solid state. The controller shall have the capability of maintaining time settings with the loss of applied AC power.

The controller shall be capable of providing a minimum of 3 different cycles, 3 offsets per cycle, 4 splits per cycle, and 3 signal plans with individual control of at least 24 signal output driving circuits in each of the intervals. These functions shall be accomplished by a microprocessor to implement the control logic and modular construction with keyboard entry of operating data.

(2) Cycle Lengths. The controller shall be capable of operating on a minimum of 3 manually or remotely selectable dials, each programmable to a maximum length of 255 seconds in 1 second increments. The duration of each cycle shall be entered into the controller memory by a front panel control.

Dial transfer from one dial to another shall occur at the end of the timing interval in effect at the time of request for transfer. Intervals may be programmed to inhibit transfer. Dial transfer shall cause no irregular interval timing or out of step operation of the controller.

(3) Offsets. Each dial shall be capable of being programmed with up to 3 offsets. Each offset shall be remotely or manually selectable.

Offsets shall be programmable from 0 to 255 seconds in 1-second increments. An offset shall be the time from the receipt of a synchronization pulse to the beginning of the dwell interval. Offset timing may be in terms of percent of cycle as well as seconds. It shall be possible to program the signal display interval in which a re-synchronization dwell occurs. It shall also be possible to program the maximum time duration of the dwell per dial. The maximum time duration shall be set independently for each dial.

(4) Interval Timing. The controller shall allow signal sequences to be programmed up to 24 intervals. Each interval can be 0.0 to 12.7 seconds in length in 0.1 second steps or 0 to 127 seconds in 1 second steps. Interval times are entered through the front panel. Interval timing may be in percent of cycle or in seconds.

Interval times may be entered for up to 24 intervals for each of the cycle lengths. No intervals shall be required to be set to zero time as the signal sequence can be programmed to the exact number of timing intervals without the necessity of establishing

dummy intervals. Intervals programmed to zero time shall be skipped.

(5) Sequence Control. Each controller shall have a programmable sequence and display control element. This element shall allow for programming at least 24 signal output driving circuits in 24 different interval display combinations.

The sequence control element shall be a non-volatile memory device (programmable read only memory, PROM) mounted for ease of removal.

(6) Front Panel Displays and Features. The front panel display shall be either an LED or LCD Decimal Digital Display that will display intervals, interval durations, cycles, offsets, and dwell maximum duration.

	Ranges
• Cycle	0-255 seconds
• Offset	0-255 seconds
• Interval	1-24
• Interval time	0-127 seconds
• Dwell	0-99.9 seconds

The indicators on the front panel shall be as follows:

- Clock. A timing indicator shall be provided on the front panel of the controller. This timing indicator shall pulse each second as long as the controller is timing. Pulsing shall be inhibited when the controller is dwelling, in manual synchronization, and/or in manual operation.
- Stop-Timing. An indicator on the front panel shall show that the unit is in the stop timing mode.
- Offset. Indicators shall show the offset that is currently being selected.
- Dial. Indicators shall show which of the dials is currently active.

(7) Remote Operations. The controller shall be capable of remote operation from a master controller of the same design that allows for 3 cycles, 3 offset per cycle operation.

The unit can be installed in a standard multidial, 3 cycle, 3 offset system that utilizes a solid state master controller and

120 VAC interconnection or other type of interconnection that outputs Dial 2, Dial 3, Offset 1, Offset 2, Offset 3, and Flash.

The controller shall work in systems when a momentary (0.5 to 2.0 second) absence of offset input is identified as a synchronization pulse.

The controller shall operate in interconnected systems with centrally located offset interruptions.

(c) Cabinet. The cabinet shall comply with Subsection 701.02(c).

(d) Cabinet Auxiliary Equipment. The Cabinet Auxiliary Equipment shall comply with Subsection 701.02(d).

(e) Certification. The supplier shall provide a certification to the Contractor of compliance with the above requirements and that the controller and conflict monitor comply with the latest NEMA specifications. This certification shall be transferred to the Department.

(f) Mounting Pad. When required, a mounting pad shall be constructed as shown on the plans or as directed by the Engineer.

702.03 Construction Requirements. The solid state controller shall be mounted as shown on the plans or as directed by the Engineer, and shall in no case be located less than 3' (1 m) from the pavement edge.

The Contractor shall furnish and properly install each cabinet and controller with accessory equipment and perform any and all necessary splicing and connections, testing of circuits, adjustments, and such other operations as may be necessary to ensure that each complete traffic signal installation, with all of its components, be completely integrated and tested as a unit so that the desired control of the intersection is attained, complete, and in proper working order and to the satisfaction of the Engineer. The Contractor shall meet with the City or County and provide them with instructions on the adjustments of the controller and provide consultation for replacement parts stocking.

702.04 Method of Measurement. Pre-Timed Controllers (Local, Local/Master) will be measured by the unit. One unit shall include the controller; the controller cabinet; the pad on which the cabinet is installed, when required; and all hardware required for installing the cabinet.

702.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Pre-Timed Controller (Local, Local/Master), which price shall be full compensation for furnishing the cabinet and controller; for mounting the controller cabinet; for installing, wiring, and testing the controller; for excavation and backfilling; for construction of the mounting pad; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Pre-Timed Controller (Local, Local/Master)	Each

SECTION 703
FLASHING BEACON CONTROLLER

703.01 Description. This item shall consist of furnishing and installing solid state flashing beacon controllers according to these specifications and at the locations shown on the plans or as directed.

703.02 Materials. Single or two circuit flashers, whichever is specified, shall be provided with a dust-tight and weatherproof aluminum alloy or stainless steel cabinet. Cabinets shall not be painted unless otherwise specified.

The cabinet shall be adaptable for mounting the flashing unit conveniently and easily. The door on the controller cabinet shall be provided with a standard locking device. The Contractor shall furnish two keys for the lock to the City or County.

The flashing unit shall be a solid state, plug-in type flasher requiring no lubrication. The flashing unit shall include a radio interference suppressor. A 30 amp circuit breaker shall be installed in the controller cabinet.

Each flashing unit shall be designed for a minimum 10 amp load with an operating voltage of 115 VAC, 60 Hz. The flasher shall be capable of providing 50-60 flashes per minute. The illuminated period of each flash shall not be less than 1/2 and not more than 2/3 of the total cycle. The unit shall be compact and readily accessible inside the cabinet.

A timing device regulating periods when the controller is operative shall be provided when specified.

The Contractor shall submit to the Engineer for approval two copies of the applicable brochures containing design criteria for the components. The specific items proposed for use shall be clearly marked in the brochures. If more than one item is submitted at one time for Department review, a list shall be attached showing each item for which Department approval of design characteristics is being requested. The Engineer will provide written approval of the design characteristics.

703.03 Construction Requirements. The flashing unit, with cabinet, shall be mounted as shown on the plans or as directed.

703.04 Method of Measurement. Flashing Beacon Controllers will be measured by the unit.

703.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Flashing Beacon Controller, which price shall be full compensation for furnishing, installing, and wiring the controller; for mounting the cabinet; and for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Flashing Beacon Controller	Each

SECTION 704
LOOP DETECTOR

704.01 Description. This item shall consist of furnishing and installing vehicle detectors and/or rack mounted vehicle detectors, loop wiring and/or preformed detector loops, and necessary feeder wire according to these specifications and at the locations shown on the plans or as directed.

704.02 Materials. (a) General. Each loop detector shall be composed of all components necessary to provide for the detection

of vehicles constituting one traffic phase and shall include an electrical surge protection device.

Each vehicle detector shall be supplied complete with comprehensive instructions. The instructions shall be placed in the controller cabinet.

The term "vehicle detector" as used in these specifications shall refer to the pulse amplifying unit located in the controller cabinet.

The term "loop wiring" as used in these specifications shall refer to the sensing element and single conductor wire from the sensing element to the feeder wire. The wire shall be 14 gage stranded copper wire and shall be insulated with RHH or RHW USE rated insulation not less than 0.045" (1.1 mm) thick.

The term "feeder wire" as used in these specifications shall refer to the shielded 1, 2, or 4 pair 14 gage stranded copper wire extending from the detector unit to the loop wiring at the curb or pavement edge. The wire in each pair shall be twisted and each pair shall be shielded. Each loop shall have a separate feeder wire unless noted otherwise on the plans.

All vehicle detectors at a given intersection shall be housed inside the controller cabinet for that intersection.

The Contractor shall submit to the Engineer for approval two copies of the applicable brochures containing design criteria for the components. The specific items proposed for use shall be clearly marked in the brochures. If more than one item is submitted at one time for Department review, a list shall be attached showing each item for which Department approval of design characteristics is being requested. The Engineer will provide written approval of the design characteristics.

(b) Vehicle Detector Requirements. Vehicle detectors shall:

- be designed to operate satisfactorily in temperatures ranging from -30° F to +140° F (-34° C to +60° C),
- be designed to operate satisfactorily on line voltage ranging from 100 to 130 VAC,
- operate on 115 VAC, 60 Hz power,
- be so designed that the detector, operating in the pulse mode, will ignore a vehicle parked over a loop or

portion thereof in 30 to 180 seconds. After ignoring the parked vehicle, the remainder of that loop shall detect additional vehicles,

- be capable of giving detection signals persisting for up to 5 minutes if a vehicle stops and remains over the loop when operating in the presence mode,
- be capable of detecting vehicles ranging in size from a motorcycle to a large tractor trailer,
- be designed to run feeder wire in common conduit with signal and interconnect cable without interference, and
- be capable of driving 1 or 2 loops over a feeder length totaling up to 600 feet (180 m).
- be equipped with optical coupled or relay output circuts.
- be equipped with transformer isolation for loops.
- be equipped with high intensity LED indicators.
- be equipped with continuous loop monitor
- be equipped with time delay (where specified in the plans)

"With Count" specified detectors shall meet the above requirements and the "Count Output" function shall provide a separate pulse for each vehicle entering the loop detection zone to a separate controller input (in addition to the standard detector output).

(c) Electrical and Mechanical Requirements. The vehicle detector unit shall be:

- plug connected to controller terminal facilities,
- completely self contained, self tuning, and shall not require external power supplies other than line voltage, and
- of a design suitable for shelf mounting inside the controller cabinet.

(d) Preformed Detector Loops. This item shall be constructed utilizing an approved preformed loop listed on the Department's Qualified Products List.

The preformed detector loop shall be constructed of #20 AWG (minimum) stranded copper wire, encapsulated in a flexible sealant inside a reinforced 250 psi (1724 kPa) rubber hose or approved

tubing. No wire splices will be allowed in the loop assembly. Hose for the loop and lead-in shall be one continuous piece except for the required tee connectors. Encapsulated wire shall have two (2) turns for loops with a perimeter greater than 40′ (12 m); or three (3) turns for perimeter less than or equal to 40′ (12 m). Quadrupole loops shall be two turn (2-4-2) configuration.

(e) Rack Mounted Vehicle Loop Detectors. Rack mounted vehicle detectors shall consist of the following principal components: two (2) or four (4) channel vehicle detector (card rack type); power supply unit (card rack type); and card rack (for plug-in modules). The components shall have the features shown below.

(1) Vehicle Detectors – Rack Mount. The single module will operate the detectors from a 24 VDC supply. Each detector shall meet the requirements of (b) above and the following:

- Connectors shall consist of double sided edge card connectors.
- "With Count" detectors shall provide two standard detector outputs and two count outputs to insert into a four channel rack position.

(2) Power Supply Unit. The power supply unit shall be a card rack type with an input voltage of 90 – 135 VAC, 60 Hz. Output voltage shall be unregulated DC. The unit shall contain high intensity LED indicators and one power switch that switches input line voltage for all channels. The unit module shall be fully compatible with the rack mounted vehicle detectors and other associated equipment.

(3) Card Rack. The vehicle detector card rack shall be constructed of lightweight anodized aluminum with mounting flanges to allow mounting of the rack either above or below the controller cabinet shelf. Each rack shall accommodate a minimum of two – 4 channel power supply units and up to eight – 2 channel detector units. Each rack shall be able to hold a maximum module size of 4.5″ x 6.875″ (115 mm x 175 mm). The connector wire shall be #22 AWG-Type UL 1015-1050C. The rack unit shall be fully compatible with the digital loop detectors and other associated equipment.

704.03 Construction Requirements. (a) General. The vehicle detectors, loop wiring, and feeder wire shall be installed as shown

on the plans or as directed by the Engineer. The loop wiring shall be installed in a sawed slot 1/4" to 3/8" (6 mm to 10 mm) wide, 2½" (65 mm) minimum depth in asphalt or 1½" (40 mm) in concrete, or as indicated on the plans. In no case shall the wire be less than 1¼" (32 mm) below the final pavement surface. Before sealing the slot, the wire shall be held down by backer rod wedges inserted into the slot at a maximum of 2' (0.6 m) intervals.

Loop wiring shall be tested by the Contractor according to the procedures outlined on the plans.

There shall be no splices in the feeder wire or the loop wiring.

The backer rod and sealant used shall be listed on the QPL. The installation procedures shall be according to the manufacturer's recommendations.

(b) Preformed Detector Loops. Preformed Detector Loop shall be designated by the perimeter size and configuration. The Contractor shall be responsible for determining the length of lead-in from loop to connection with feeder wire. Lead-in from feeder wire to the loop shall be considered incidental to the Preformed Detector Loop.

The preformed loop shall be placed in a saw-cut slot of sufficient width (approximately ½″ [6 mm] to ¾″ [19 mm] in width) to a depth such that the top of loop is a minimum of 4″ (100 mm) below the final surface, for the entire length of the trench. The maximum width of any loop trench shall be 1½″ (38 mm). The minimum width shall be 1/8″ (3 mm) larger than the outer diameter of the preformed loop. Larger widths shall be used for couplings, tees, and ells but not to exceed the maximum width. The corners of the trench should be chiseled to remove the sharp edge. The Engineer may approve other methods of trenching.

Where the road surface is to be overlaid, the preformed detector loops shall be installed prior to final surface. The Contractor shall seal and compact the loop trench completely with a material and/or sealant recommended by the loop manufacturer. The recommended material shall be able to repair asphalt and concrete roads and not require removal and/or replacement if the pavement is to be overlaid. Where surface is not to be overlaid, an approved sealer shall be applied to backfill the preformed loop trenches as needed to a minimum depth of 3/8″ (10 mm). The approved material shall

have a minimum settlement period of 14 days prior to each backfill application.

The connection of the loop lead-in to the feeder wire shall be soldered and completely sealed in an approved manner against entry of moisture into the splice, jacket of loop and feeder wire. The preformed detector loop shall be tested for meg and continuity according to the procedures outlined on the plans and each feeder wire shall be clearly labeled with the phase designation.

(c) Rack Mounted Vehicle Detectors. Wiring diagrams for the vehicle detector channel assignment shall be provided to the Department for approval prior to the delivery of the controller cabinet to the Contractor.

The vehicle detector card rack's mounting flanges shall be turned out on each rack and the power supply modules shall be located on the left side when viewed from the front.

All output channels available from the card rack, including unused channels, shall be brought out to the terminal strips for future use. This shall include providing terminals for future detector loops. Where unused system detector inputs to the controller are available, these shall be tied to unused detector channels or brought out to the terminal facilities.

If approved by the Engineer, 2-channel units may be used in combination with 4-channel units in order to reduce the number of unused channels. This may be allowed provided that the possibility of cross talk will not be increased.

704.04 Method of Measurement. Items will be measured as follows:

(a) Vehicle Detectors will be measured by the unit.

(b) Loop Wiring will be measured by the linear foot (meter).

(c) Feeder Wire will be measured by the linear foot (meter).

(d) Preformed Detector Loops will be measured by the unit for the size, type, and number of turns specified. Size shall be designated by length and width dimensions. Type shall be Q for quadrupole configuration (2-4-2) and blank for standard configuration.

(e) Vehicle Detector - Rack Mount will be measured by the unit for the number of standard vehicle detector channels provided.

(f) Vehicle Detector - Rack Mount, with Count will be measured by the unit for the number of standard vehicle detector channels provided (including one separate count output channel). No separate payment will be made for count output channels.

(g) Vehicle Detector - with Count will be measured by the unit for the number of standard vehicle detector channels provided (including one separate count output channel). No separate payment will be made for count output channels.

704.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for as follows:

(a) Vehicle Detectors will be paid for at the contract unit price bid per each for Vehicle Detector, or Vehicle Detector-with Count, which price shall be full compensation for furnishing, mounting, and installing the detector; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

(b) Loop Wiring will be paid for at the contract unit price bid per linear foot (meter) for Loop Wiring, which price shall be full compensation for laying the loop wiring in place and connecting to the appropriate feeder wire; for sawing and sealing as appropriate; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

(c) Feeder Wire will be paid for at the contract unit price bid per linear foot (meter) for Feeder Wire, which price shall be full compensation for laying the feeder wire in place and connecting to the appropriate vehicle detector and loop wiring; for pulling wire through conduit; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

(d) Preformed Detector Loops will be paid for at the contract unit price bid per each for Preformed Detector Loop (__′ x __′) (__ m x __m), which price shall be full compensation for sawing and sealing; clearing the slot; removal of surplus material; placing the preformed detector loop in place and connecting to the appropriate feeder wire; and for all materials including the preformed loop, asphalt or sealer material, coupling and connectors; and for all labor, equipment, tools, and incidentals necessary to complete the work.

(e) Rack Mounted Vehicle Detectors will be paid for at the contract unit price bid per each channel for Vehicle Detectors-Rack Mount or Vehicle Detectors-Rack Mount, with Count, which price shall be full compensation for furnishing and installing the detector card rack, power supply, detector cards, and for all equipment, tools, labor, and incidentals required to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Vehicle Detector	Each
Vehicle Detector-with Count	Each
Loop Wiring	Linear Foot (Meter)
Feeder Wire	Linear Foot (Meter)
Preformed Detector Loop (__′ x __′) (__ m x __m)	Each
Vehicle Detector-Rack Mount	Each
Vehicle Detector-Rack Mount, with Count	Each

SECTION 705
LOOP WIRING IN DUCT

705.01 Description. This item shall consist of furnishing and installing vehicle detector loop wiring according to these specifications and at the locations shown on the plans or as directed.

705.02 Materials. The term "loop wiring" as used in these specifications shall refer to the sensing element (loop), which is the single conductor wire coming from and going to the feeder wire at the curb or pavement edge. Loop wiring shall consist of 14 gage, stranded XHHW or THHN 600V wire completely enclosed in a PVC or polyethylene tubing having a 3/16" (4.75 mm) I.D., 1/4" (6.35 mm) O.D., and a wall thickness of 1/32" (0.8 mm). Loop wiring in duct shall comply with the latest requirements of *International Municipal Signal Association Specification No. 51-5*. The tubing shall be capable of resisting deterioration from oils and solvents. The tubing shall also be highly abrasion resistant and have a smooth bore.

705.03 Construction Requirements. The loop wiring shall be installed in a sawed slot 3/8" (10 mm) wide by 2½" (65 mm) deep cut in the roadway surface. The loop wire shall be inserted into the tubing for the full length from the point of splicing at the curb or pavement edge and placed into the slot with the number of turns as shown on the plans or as directed by the Engineer. Twisting of loop wire from the perimeter of the loop to the pull box is not required. The tubing shall be of a continuous length from the point of splicing of the loop wire to the feeder wire. No splices will be made in the tubing or loop wiring. The ends of the tubing shall be sealed to prevent any entrance of moisture into the tubing. The electrical splice between the loop wiring and feeder wire shall consist of providing a watertight protective covering for the spliced wire, the shielding on the feeder wire, and the end of the tubing containing the loop wiring. To eliminate floating when the sealant is poured, the tubing shall be held down by wedges inserted into the slot on 2' (0.6 m) centers. The wedges shall be 1" (25 mm) sections of plastic tubing, folded before insertion. The sealant used shall be listed on the QPL. The installation procedures shall be according to the manufacturer's recommendations.

705.04 Method of Measurement. Loop Wiring in Duct will be measured by the linear foot (meter).

705.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per linear foot (meter) for Loop Wiring in Duct, which price shall be full compensation for furnishing and installing the loop wire and protective tubing; for sawing and sealing the slot; for splicing the wires complete in place; and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Loop Wiring in Duct	Linear Foot (Meter)

SECTION 706
TRAFFIC SIGNAL HEAD

706.01 Description. This item shall consist of furnishing and installing 12" (300 mm) diameter traffic signal heads of the type specified and according to these specifications and at the locations shown on the plans or as directed.

706.02 Materials. (a) General. Each traffic signal head shall consist of an assembly of one or more signal faces and the necessary mounting brackets and hardware.

Each signal face shall consist of an assembly of signal sections in sufficient quantity to provide the required number of indications. The sections shall be joined together in a manner that provides both mechanical integrity and a weatherproof unit.

Each signal section of a signal face shall consist of a housing, door, visor, and optical assembly. The housing, door, and lens, together with necessary gaskets, shall constitute a weatherproof unit. The lens and the remainder of the optical assembly, together with necessary gaskets, shall constitute a dust-tight assembly.

Each signal section and its associated optical system shall be capable of operating satisfactorily with the section's axis either vertical or horizontal.

Each signal section shall be provided with openings in the top or bottom for mounting purposes. Each opening shall be round to accommodate 1½" (40 mm) pipe. Each unused opening shall be closed with a gasketed plug.

Each signal face shall be capable of being rotated 360° about its vertical axis and shall be capable of being locked at 5° intervals. Locking shall be accomplished by the engagement of serrations in the end signal sections with similar serrations in the mounting bracket assembly.

Signal indications shall be assembled according to the latest revisions of the MUTCD.

The Contractor shall submit to the Engineer for approval two copies of the applicable brochures containing design criteria for the components. The specific items proposed for use shall be clearly marked in the brochures. If more than one item is submitted at one

time for Department review, a list shall be attached showing each item for which Department approval of design characteristics is being requested. The Engineer will provide written approval of the design characteristics.

(b) Optical Unit. Each optical unit shall consist of an assembly of a lens, reflector, lamp, lamp socket, and other components as required. The optical assembly together with the necessary gaskets shall constitute a dust-tight assembly that shall be designed to give clear visible signal indications within an angle of at least 45° and from 10' to 300' (3 m to 90 m) under all light and atmospheric conditions. The optical assembly shall be designed to minimize the return through the lens of outside light entering the lens at low sun angles to prevent the effect termed Sun Phantom.

Lenses shall be of the color indicated, circular in shape, and made of either glass or ultraviolet stabilized plastic. The composition must be durable on prolonged exposure to weather and all lenses shall be uniformly colored throughout the body of the material, true to size and form, and free from any defects that in any way detract from their efficiency or use. Each lens shall be so designed and manufactured that, when installed in a standard traffic signal, it will satisfy the minimum requirements for candlepower distribution and intensity and chromaticity as specified by the ITE. When mounted, the lens shall have a visible diameter of not less than 11½" (292 mm) as shown on the plans. Lenses shall be marked to indicate the top.

The reflectors shall be of Alzak aluminum and shall comply with the specifications of the ITE Technical Report #1. Aluminum reflectors shall be of high purity aluminum, spun to shape and treated by the Alzak Process. The reflectors shall be of the pressure type, free floating, and must ensure full seal against the lens gasket.

Reflectors shall be mounted in a cast aluminum reflector support attached to the housing, or shall be an integral reflector and support of formed sheet aluminum, or shall be supported in such a fashion that the alignment of all optical components is maintained except when purposely disassembled.

The reflector support assembly, if used, shall be pivoted to the housing and designed so that it can be swung out or easily removed without the use of any tools.

The method of mounting and fastening reflectors shall ensure proper alignment between the lens and reflector when the door is closed.

The construction of the signal head and its components shall be such that the fit between the reflector and the lens will eliminate all possibility of false indications.

Reflectors shall have an opening in the back for the lamp socket.

The lamp socket shall be made of molded Bakelite and the screw shall be so arranged that the lamp will not loosen due to vibration. A lamp socket support shall be provided that can be assembled or removed without the use of tools. Each socket shall be wired with one black lead from the socket and one white lead from the shell. Leads shall be of sufficient length to reach the terminal block with the reflector fully open and shall be of 18 gage AWG wire with thermoplastic insulation, 600 volt dielectric strength at 220° F (105° C) temperature.

Each optical unit shall be supplied with a lamp of appropriate size to comply with the standards set forth in the latest ITE *Standard for Traffic Signal Lamps*. Lamps shall be rated for 8,000 hours for their intended use.

(c) Housing. The signal head housing shall consist of an assembly of separate sections substantially secured together in a watertight manner to form a unit of pleasing appearance. Each section shall house an individual optical unit. Each housing shall be equipped with the suitable fittings required for mounting.

The sections shall be interchangeable and so constructed that each section can be removed or added. Each section shall be assembled with 2 plated washers and 3 plated bolts. Each cap shall be drilled for slip fit of a standard 1½" (40 mm) pipe nipple. The area around this opening shall be reinforced and serrated so that serrated fittings may be used to secure the housing. A terminal block of an approved type shall be mounted inside and at the back of the housing.

All mounting brackets and fittings shall be assembled watertight. Brackets shall be 1½" (40 mm) standard pipe or rigid conduit of sufficient strength to withstand the vertical and horizontal loads specified by ITE.

706

Each housing shall be made using one of the following methods and materials:

- Cast from aluminum alloy. Material for die cast housings shall comply with ASTM B 85 aluminum alloy S-12A, S-12B, SC-84A, SC-84B, or SG-100B. Material for permanent mold castings shall comply with ASTM B 108 aluminum alloy B443.0.
- Molded from structural plastic. Material for molded housings (injection, rotational, or blow molded) shall be made from an engineering structural plastic. Plastic shall be ultraviolet and heat stabilized and flame resistant. Plastic housings may be either molded in one piece or may be fabricated from 2 or 3 pieces joined into a single piece using thermal, chemical, or ultrasonic bonding.

Unless otherwise specified on the plans, plastic shall be used.

Each door shall be composed of one of the above materials and shall be compatible with the material of the housing.

The lens opening in the doors shall provide a visible diameter of not less than 11½" (292 mm) nor more than 12" (300 mm) for a nominal 12" (300 mm) round lens.

All exterior metal parts, except as noted and including hinge pins, shall be made from stainless steel.

Visors and backplates for metal signal sections shall be made from 0.064" (1.6 mm) minimum thickness aluminum alloy sheet.

Visors and backplates for plastic signal faces shall be either formed from sheet plastic or assembled from one or more injection, rotational, or blow molded plastic sections.

Each visor shall be of the open bottom tunnel type, a minimum of 9½" (240 mm) in length for nominal 12" (300 mm) round lens, and not less than 0.05" (1.25 mm) in thickness, with a minimum downward tilt of 3½ degrees.

Gaskets shall be made from neoprene or silicone rubber; resistant to heat, permanent deformation, and weather; and compatible with the materials of the door, housing, and lens.

The door of each signal section shall be a one piece door hinged to the housing so as to permit access to the section for replacement of bulbs. The optical systems shall be so mounted on the door that the various parts may be swung open for ready accessibility and removal. The door shall be secured with simple devices and a non-corrosive door locking device to provide for opening and closing the door without the use of special tools.

All exterior parts of the signal head, except the lens and mounting brackets, shall be finished with 2 coats of synthetic resin enamel of the color specified herein. Nonmetallic materials shall have the color impregnated in the resin material. Unless otherwise specified on the plans, colors shall be as listed below:

- Housing - Black
- Door Assembly - Black
- Visor - Flat Black

The color of the mounting bracket shall match the color of the traffic signal head or the color of the traffic signal pole.

(d) The Contractor shall furnish and install the proper signs [either Left Turn Signal or Left Turn Yield on Green (symbolic green ball, MUTCD R10-12)] adjacent to signal heads controlling an exclusive left turn lane. The sign size and layout shall be as shown on the plans and shall comply with Section 723. Unless otherwise specified, the sheeting shall be Type III or IV.

706.03 Construction Requirements. Signal heads shall be installed to maintain a 18'-0" (5.5 m) maximum and 17'-0" (5.2 m) minimum vertical clearance directly under the signal head.

706.04 Method of Measurement. Traffic Signal Heads will be measured by the unit. One unit shall include the number of faces and sections specified, together with all mounting brackets and hardware; signs, where required; and other incidentals to provide a signal head complete in place.

706.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Traffic Signal Head of the type and size specified, which price shall be full compensation for furnishing and installing all materials and signs; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Traffic Signal Head (_____)	Each

SECTION 707
PEDESTRIAN SIGNAL HEAD

707.01 Description. This item shall consist of furnishing and installing pedestrian signal heads and accessories according to these specifications and at the locations shown on the plans or as directed.

707.02 Materials. The pedestrian signals shall be the incandescent type with WALKING PERSON (symbolizing WALK) and UPRAISED HAND (symbolizing DON'T WALK) signal indicators. The symbol designs set forth in the FHWA publication "Standard Highway Signs" shall be used. The WALKING PERSON signal shall be as specified by the ITE and produced with a white glass lens with all but the symbol obscured by an opaque material. The symbol shall be a minimum of 6" (150 mm) in height.

The UPRAISED HAND signal shall be as specified by the ITE and shall be produced with an orange glass with all except the symbol obscured by an opaque material. The symbol shall be a minimum of 6" (150 mm) in height.

The signal shall be 12" x 12" (300 mm x 300 mm) nominal size and provided with lens visors. The reflectors and housings shall comply with Subsection 706.02. When the traffic signal controller is the actuated type, the pedestrian signals shall also be the actuated type.

Pedestrian-actuated signals shall have a push-button detector 3½' to 4' (1 m to 1.2 m) above the surface of the sidewalk at each end of the crosswalks. The push-button detector shall be located on a traffic signal pole or a pedestrian signal pedestal pole. The standard pedestrian-actuated signal sign (MUTCD R10-3e) shall be mounted just above the push-button. The sign shall comply with the requirements of Section 723. Unless otherwise specified, the sheeting shall be Type III or IV.

The Contractor shall submit to the Engineer for approval two copies of the applicable brochures containing design criteria for the components. The specific items proposed for use shall be clearly marked in the brochures. If more than one item is submitted at one time for Department review, a list shall be attached showing each item for which Department approval of design characteristics is being requested. The Engineer will provide written approval of the design characteristics.

707.03 Construction Requirements. Pedestrian signals shall be mounted with the bottom of the signal not less than 8' (2.4 m) nor more than 10' (3.0 m) above the sidewalk level and so that there is a signal in the line of vision of pedestrians crossing in any direction. The pedestrian signal head shall be so positioned and adjusted as to provide maximum visibility at the start of the controlled crosswalk. The signal shall be wired to operate upon actuation from the pedestrian push-button when the controller is the traffic actuated type.

707.04 Method of Measurement. Pedestrian Signal Heads will be measured by the unit. One unit shall include one complete signal assembly consisting of both WALK and DON'T WALK sections; pedestrian actuated push button detectors and signs, when required; and all wiring except signal cable necessary to provide a complete functioning unit.

707.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Pedestrian Signal Head, which price shall be full compensation for furnishing and installing all materials and signs; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Pedestrian Signal Head	Each

SECTION 708
TRAFFIC SIGNAL CABLE

708.01 Description. This item shall consist of furnishing and installing traffic signal cable according to these specifications and at the locations shown on the plans or as directed.

708.02 Materials. The cable shall be #14 AWG copper with the number of conductors as shown on the plans and shall comply with the *International Municipal Signal Association Specification 20-1 or 20-3* for 600 volt polyethylene insulated and jacketed signal cable.

The Contractor shall furnish and install acceptable bands, ties, and other supports for the cable in poles and control boxes according to the best modern practice.

Cables shall be marked for phase identification according to the manufacturer's standards.

708.03 Construction Requirements. Connections to signal heads shall be made with a polyethylene jacketed stranded or solid wire cable. The Contractor will be allowed to make connections to the signal heads by the "line tapping" method.

Splices shall be moistureproof and have a dielectric strength at least equal to that of the original insulation. The sweating or soldering shall be accomplished by pouring, using solder hot enough to run properly. Splices shall be made according to the best modern practice and may be accomplished by methods approved by the Engineer. Splices will be allowed only at pull boxes, pole bases, and traffic signal heads.

708.04 Method of Measurement. Traffic Signal Cable will be measured by the linear foot (meter) in place.

708.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per linear foot (meter) for Traffic Signal Cable of the type and size specified, which price shall be full compensation for furnishing and installing all materials; making all splices and connections; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
Traffic Signal Cable (____)	Linear Foot (Meter)

SECTION 709
GALVANIZED STEEL CONDUIT

709.01 Description. This item shall consist of furnishing and installing hot dipped galvanized steel conduit of the size and at the locations shown on the plans and according to these specifications, or as directed. This item covers galvanized steel conduit installed above and below ground. This item shall also include any flexible runs to light supports; straps and bolts for attachment to poles, bridges, or other structures; fittings for connection to junction boxes, controller cabinets, and other elements of the complete installation, as required; and expansion devices.

709.02 Materials. All conduit, expansion joints, and fittings shall be hot dipped galvanized, inside and outside, according to AASHTO M 111. Conduit shall be free of all imperfections that might injure the cable. Conduit fittings and accessories shall be suitable for underground, encased, and exposed applications according to Underwriters Laboratories and the latest National Electric Code. All conduit shall comply with UL Specification UL-6. Conduit straps shall be galvanized stock, sized according to size conduit shown on plans. Nuts on conduit strap anchor studs shall be galvanized and shall be of a locking type.

Where a flexible conduit connection is required, all metal flexible galvanized steel tubing with a liquid tight neoprene jacket extruded over the flexible metal core shall be used. The fittings required for connection between the flexible conduit and rigid conduit or connection boxes shall be liquid tight and as recommended by the manufacturer of the flexible conduit. Factory fabricated flexible conduit assemblies having liquid tight characteristics are acceptable. Non-watertight conduit is not acceptable. A flexible conduit connection is required at the location of all bridge expansion joints.

709.03 Construction Requirements. Underground conduit shall be installed in trenches or predrilled tunnels not less than 12" (300 mm) below final grade except where otherwise indicated on the

plans or directed. Trench excavation, backfill, compaction, and disposal of surplus material shall be performed to the satisfaction of the Engineer. Compaction shall be accomplished to the extent necessary to prevent future settlement of the trench. Disturbed surfaces shall be returned to their original condition.

Conduit with fittings and appurtenances may be attached to bottoms of slabs on bridges; faces of wingwalls, columns, or bent caps; or flanges and webs of steel beams. Such attachment shall be achieved by use of conduit straps spaced at intervals of 5' (1.5 m) and held in place by self-drilling anchors, expansion shield anchors, or clamps on steel flanges.

All conduit shall be reamed after threading to remove all burrs. Conduit shall be brushed thoroughly with a bristle brush before installation to remove all dirt from the inside surface. At the time of installation, each threaded end of conduit shall be coated with an acceptable sealant to form watertight joints. All coupling connections shall be made so that the reamed ends of conduit butt squarely against each other inside the coupling. Conduit ends at boxes shall be fitted with threadless bushings.

Standard bends shall be used wherever possible, but when a conduit bend is formed, the largest possible bending radius shall be used and shall not be less than 6 times the nominal diameter of the conduit.

Upon completion of each conduit run, a device having a diameter of at least 85% of the nominal diameter of the conduit shall be pulled through the conduit run. If the device does not pull through, the cause of the obstruction shall be determined and corrected. A ¼" (6 mm) nylon pull rope shall be pulled through each conduit and left in place for later use if the conduit is to be left empty.

709.04 Method of Measurement. Galvanized Steel Conduit will be measured by the linear foot (meter) measured along the axis of the conduit in its final position. It will not be considered complete until backfill and compaction have been satisfactorily performed. All necessary conduit fittings will be included as part of the conduit run and will not be measured separately.

709.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per linear foot (meter) for Galvanized Steel Conduit of the

size specified, which price shall be full compensation for furnishing and installing conduit, fittings, and drag rope; for jacking, drilling, excavation, backfill, compaction, removal of surplus material, and replacement of existing surfaces; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
Galvanized Steel Conduit (__") (___mm)	Linear Foot (Meter)

SECTION 710
NON-METALLIC CONDUIT

710.01 Description. This item shall consist of furnishing and installing PVC (polyvinyl chloride) or PE (polyethylene) conduit according to these specifications and at the locations shown on the plans or as directed. The Contractor may elect to use either type of conduit where non-metallic conduit is shown on the plans; however, each run of conduit (from pull box or pole base to the next pull box or controller) shall consist of conduit, fittings, and accessories of one type of material.

710.02 Materials. (a) PVC Conduit. Conduit, fittings, and accessories shall be PVC suitable for underground, encased, and exposed applications as approved by Underwriters Laboratories according to the National Electric Code. Conduit shall be Schedule 40 rigid PVC.

(b) PE Conduit. Conduit, fittings, and accessories shall be polyethylene, suitable for underground, encased, and exposed applications as approved by Underwriters Laboratories according to the National Electric Code. Conduit shall be Schedule 40, meeting the requirements of ASTM D 2447-99, utilizing test procedure ASTM D 1248.

710.03 Construction Requirements. Conduit shall be installed in trenches or predrilled tunnels not less than 18" (450 mm) below final grade except where otherwise indicated on the plans or as directed.

Standard bends should be used wherever possible, but when the bend is formed, the longest possible bending radius shall be used

and shall not be less than 6 times the nominal diameter of the conduit.

Upon completion of each conduit run, a device having a diameter of at least 85% of the nominal diameter of the conduit shall be pulled through the conduit run. If the device does not pull through, the cause of the obstruction shall be determined and corrected. A ¼" (6 mm) nylon pull rope shall be pulled through each conduit and left in place for later use if the conduit is to be left empty.

Trench excavation, backfill, compaction, and removal of surplus material shall be performed to the satisfaction of the Engineer. Compaction shall be accomplished to the extent necessary to prevent future settlement of the trench. Disturbed surfaces shall be returned to the original condition.

710.04 Method of Measurement. Non-Metallic Conduit will be measured by the linear foot (meter) measured along the axis of the conduit in its final position. It will not be considered complete until backfill and compaction have been satisfactorily performed. All necessary conduit fittings will be included as part of the conduit run and will not be measured separately.

710.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per linear foot (meter) for Non-Metallic Conduit, of the size specified, which price shall be full compensation for furnishing and installing the conduit, fittings, and drag rope; for excavation, backfill, compaction, removal of surplus material, and replacement of existing surfaces; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Non-Metallic Conduit (__")(___mm)	Linear Foot (Meter)

SECTION 711
CONCRETE PULL BOX

711.01 Description. This item shall consist of furnishing and installing at locations shown on the plans or as directed, a Concrete Pull Box of the type specified according to these specifications.

711.02 Materials.

The pull box cover and cover ring shall be constructed with Portland cement concrete reinforced with welded wire or shall be polymer concrete reinforced with heavyweave fiberglass or shall be high density polymer concrete reinforced with Sheet Molded Compound (SMC).

The pull box body shall be constructed with Portland cement concrete reinforced with welded wire or shall be polymer concrete reinforced with heavyweave fiberglass or shall be manufactured using the compression molded process, utilizing high density polymer concrete and SMC to produce a one-piece monolithic structure.

No fiberglass shall be exposed. All exposed portions of the pull box shall be non-electrically conductive.

The minimum inside dimensions measured horizontally across the center of the box just below the lid support lip shall be as follows:

Concrete Pull Box -- Type 1 and 1 HD:
8 ¾" (220 mm) wide x 14 ¼" (360 mm) long

Concrete Pull Box -- Type 2 and 2 HD:
11" (280 mm) wide x 21" (530 mm) long

Concrete Pull Box -- Type 3 and 3 HD:
15 ¼" (385 mm) wide x 28" (710 mm) long

The depth measured from the top of the lid shall be a minimum of 11 ½" (290 mm).A non-metal electrically insulated cover shall be provided for each pull box. The covers shall have a skid resistant surface on top and a lifting eye.

The pull box and cover shall be constructed in such a manner that the assembly will support light vehicular traffic. The cover with pull box shall meet or exceed the following test loading:

Type	Load		Load Area	
	pounds	**kg**	**Sq. inch**	**sq mm**
1	3800	1720	10 (3.16”x3.16”)	6400 (80 mm^2)
1 HD	7500	3400	10	6400
2	3800	1720	20 (4" x 5")	13,000 (100 mm x 130 mm)
2 HD	7500	3400	20	13,000
3	3800	1720	20	13,000
3 HD	7500	3400	20	13,000

Pull box with cover in place shall comply with the National Electric Code for exposed boxes rated at voltages up to 480 VAC.

All Type HD concrete pull boxes are to be installed as shown on the plans with a surrounding apron of concrete 12" (305 mm) wide and 6" (152 mm) in depth. The concrete shall comply with Section 802 for Class S Concrete. The Department will perform all acceptance sampling and testing at the frequencies shown for the Contractor acceptance testing in Subsection 802.06. Reinforcing steel shall meet the requirements of Subsection 804.02(a) for the size and grade shown in the plans and shall be placed as shown in the plans and in conformance with Subsections 804.06 and 804.07.

The pull box shall be permanently labeled with “AHTD”, “ELECTRIC”, the manufacturer’s name and model identifier. The permanent label “AHTD” and “ELECTRIC” shall be placed on the outside of the pull box lid.

711.03 Construction Requirements. Excavation for the pull box shall be to a depth that will result in the top of the cover being flush with the surrounding surface. The pull box shall be set on a gravel or crushed stone bedding that will serve as a sump. The bedding shall extend 18" to 24" (450 mm-600 mm) below the bottom of the box, and shall be constructed according to the details shown on the plans.

Concrete Pull Boxes shall be included in the Performance Test under Section 717, and any box or lid that fails for any reason during the 6-month warranty period shall be replaced by the Contractor at no cost to the Department.

711.04 Method of Measurement. Concrete Pull Boxes, in place with lids, will be measured by the unit.

711.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Concrete Pull Box of the type specified, which price shall be full compensation for furnishing and installing the pull box; for excavation, backfill, compaction, removal of surplus materials and replacement of the existing surface; for furnishing and placing the bedding material; for furnishing and placing reinforcing steel and concrete for the HD pull box aprons; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Concrete Pull Box (Type__)	Each

SECTION 712
SPAN WIRE SUPPORT POLE WITH FOUNDATION

712.01 Description. This item shall consist of furnishing and erecting steel span wire support poles with foundations according to these specifications and to the dimensions and details and at the locations shown on the plans or as directed.

712.02 Materials. The following material requirements shall apply to poles and foundations.

(a) Pole shafts shall comply with ASTM A 1011, SS, Grade 50 (345), AASHTO M 270, Grade 50 (345), ASTM A 595 Grade A, or ASTM A 572, Grade 50 or Grade 65. Galvanizing shall comply with AASHTO M 111, Thickness Grade 100.

(b) Anchor bolts shall comply with AASHTO M 314, Grade 55 (379) including supplemental requirement S1. All exposed portions of bolts shall be galvanized according to AASHTO M 232 or ASTM B 695, Class 40 or 50.

(c) Anchor base plates shall comply with AASHTO M 270, Grade 36 (250). Galvanizing shall comply with AASHTO M 111, Thickness Grade 100.

(d) Cast anchor base plates shall comply with AASHTO M 103 Grade 65-35. Galvanizing shall comply with AASHTO M 111, Thickness Grade 100, or ASTM B 695Class 40 or 50.

(e) Hex nuts shall comply with AASHTO M 292 Grade 2H or AASHTO M 291 Grade DH or DH3 (Grade 10S or 10S3). The thread series shall correspond with that of the bolt furnished. Washers shall comply with AASHTO M 293. Galvanizing shall comply with AASHTO M 232 or ASTM B 695Class 40 or 50. Nuts shall be galvanized by the same process as that of the bolts.

(f) Concrete shall comply with Section 802 for Class S concrete. The Department will perform all acceptance sampling and testing at the frequencies shown for Contractor acceptance testing in Subsection 802.06. Reinforcing steel shall comply with Section 804 for Grade 40 steel.

(g) Ground rods shall be 5/8" (16 mm) diameter Copperweld with ground wire and connections.

(h) When painting is specified on the plans, the pole and base plate shall be painted according to the provisions of Section 638.

712.03 Fabrication. The pole shall be constructed to the dimensions shown on the plans. The pole shaft shall have a continuous taper with only 1 vertical seam electrically welded and rolled smooth. A handhole of sufficient size to allow for internal wiring shall be provided near the pole base. A reinforcing frame for the handhole tapped for a grounding bolt shall be welded into the shaft a short distance from the base. A J-hook wire support shall be welded inside the shaft near the top of the pole.

A cast steel or plate anchor base of the size and shape shown on the plans shall be electrically welded to the bottom of the pole. The anchor base and welding thereto shall develop the full strength of the adjacent shaft.

Four anchor bolts with hex leveling nuts shall be provided with each pole. The anchor bolts shall be of the length shown on the plans and have an L-bend on the bottom and shall be threaded at the top.

Before installation, the Contractor shall furnish to the Engineer design details regarding this item. These details shall specify materials and shall include a certification prepared and/or approved by a Professional Engineer who is registered in any of the United States:

- That the design complies with the plans and specifications and meets or exceeds the standards found in AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals 4th Edition (2001)* with 2003 and 2006 interims.
- That the materials specified in the design meet or exceed the requirements of Subsection 712.02.

The Contractor shall also furnish a certification from the manufacturer or supplier that the span wire support pole was fabricated in compliance with the certified design and that the materials furnished comply with the specifications.

712.04 Construction Requirements. The Contractor shall contact the local utility companies to determine the location of underground utilities in the area where the foundations are to be located and shall be responsible for repairing, to the satisfaction of the utility company, any damaged utilities.

Excavation, backfill, compaction, and disposal of surplus materials shall be performed to the satisfaction of the Engineer. Compaction shall be accomplished to the extent necessary to prevent future settlement of the backfill. Disturbed surfaces shall be returned to their original condition.

Foundations for span wire support poles shall be constructed in firm earth to the minimum size and depth shown on the plans. The location of the foundations shall be as shown on the plans or as

directed by the Engineer. Foundations shall be placed monolithically and have a 1" (25 mm) chamfer at the top.

Conduit, anchor bolts, and ground rods shall be placed in proper position and shall be held in place by means of a template until the concrete sets. Concrete shall be constructed according to Section 802. The exposed portion of the foundation shall be given a Class 2 finish. The area between the top of the foundation and the pole base shall be neatly grouted after the pole has been raked and secured in place. The pole shall not be erected upon the foundation for a minimum of 72 hours after placement of the concrete.

Span wire support poles shall be securely bolted to the foundation in a raked position employing galvanized leveling nuts.

Span wire support poles shall be effectively grounded by means of a ground rod. The grounding wire shall be attached to the pole by means of a solderless steel bolt.

Subsequent to erection, any damaged galvanized coating or paint shall be repaired according to Subsection 807.88 or Section 638, as appropriate.

All holes in span wire support pole required for eye bolts, signal cable, controller mounting, etc., shall be machine drilled.

712.05 Method of Measurement. Span Wire Support Poles with Foundations will be measured by the unit.

712.06 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Span Wire Support Pole With Foundation, which price shall be full compensation for furnishing and installing the pole; for excavation, backfill, compaction, and removal of surplus material; for furnishing and placing reinforcing steel and concrete; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Span Wire Support Pole With Foundation	Each

SECTION 713
SPAN WIRE ASSEMBLY

713.01 Description. This item shall consist of furnishing and installing span wire assemblies according to these specifications and at the locations shown on the plans or as directed.

713.02 Materials. The supporting strand shall be a continuous length of suspension strand without splices, except for the Y connection and insulator joint, and shall be attached to steel poles at each end as shown on the plans.

The span wire shall comply with ASTM A 475 and shall be a nominal 5/16" (8 mm) extra high strength 7 wire strand and shall have a Class A galvanized coating.

Suitable cable ties shall be provided to suspend the traffic control cable at intervals not to exceed 18" (450 mm). Necessary eyebolts, washers, nuts, and fittings shall be of galvanized steel complying with AASHTO M 232 or M 298, Class 40 or 50.

713.03 Construction Requirements. Before erecting the span wire, the Contractor shall determine the length of suspension strand required to span the distance between poles, allowing 5% for sag plus connections.

After the span wire has been assembled and the signal heads suspended, the Contractor shall adjust the assembly to obtain a maximum of 18'-0" (5.5 m) and a minimum of 17'-0" (5.2 m) clearance from the bottom of the signal head to the pavement.

713.04 Method of Measurement. Span Wire Assemblies will be measured by the unit.

713.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Span Wire Assembly, which price shall be full compensation for furnishing and erecting the assembly; for all fittings, clamps, and insulators; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
Span Wire Assembly	Each

SECTION 714
TRAFFIC SIGNAL MAST ARM AND POLE WITH FOUNDATION

714.01 Description. This item shall consist of furnishing and erecting steel traffic signal mast arms and poles with foundations according to these specifications and to the dimensions and details and at the locations shown on the plans or as directed.

714.02 Materials. The following material requirements shall apply to mast arms, poles, and foundations.

(a) Poles and mast arms shall be ASTM A 1011, SS, Grade 50 (345), AASHTO M 270, Grade 50(345), ASTM A 595 Grade A or ASTM A 572, Grade 50 or Grade 65. Galvanizing shall comply with AASHTO M 111, Thickness Grade 100.

(b) Anchor bolts shall comply with AASHTO M 314, Grade 55 (379), including Supplementary Requirement S1. All exposed portions of bolts shall be galvanized according to AASHTO M 232 or ASTM B 695, Class 40 or 50.

(c) Anchor Base Plates shall be AASHTO M 270 Grade 36 (250). Galvanizing shall comply with AASHTO M 111, Thickness Grade 100.

(d) Cast Anchor Base Plates shall be AASHTO M 103/M 103M Grade 65-35. Galvanizing shall comply with AASHTO M 111, Thickness Grade 100, or ASTM B 695, Class 40 or 50.

(e) Hex nuts shall comply with AASHTO M 292 Grade 2H or AASHTO M 291 Grade DH or DH3 (Grade 10S or 10S3). The thread series shall correspond with that of the bolt furnished. Washers shall comply with AASHTO M 293. Galvanizing shall comply with AASHTO M 232 or ASTM B 695, Class 40 or 50. Nuts shall be galvanized by the same process as that of the bolts.

(f) Clamp Plates shall be AASHTO M 270 Grade 36 (250). Galvanizing shall comply with AASHTO M 111, Thickness Grade 100.

(g) Flange and Gusset Plates shall be AASHTO M 270 Grade 36 (250). Galvanizing shall comply with AASHTO M 111, Thickness Grade 100.

(h) Clamp and Flange Bolts shall be AASHTO 164M. Galvanizing shall comply with AASHTO M 232 or ASTM B 695, Class 40 or 50.

(i) Concrete shall comply with Section 802 for Class S concrete. The Department will perform all acceptance sampling and testing at the frequencies shown for Contractor acceptance testing in Subsection 802.06. Reinforcing steel shall comply with Section 804 for Grade 40 steel.

(j) Ground rods shall be 5/8" (16 mm) diameter or larger Copperweld with ground wire and connections.

(k) When painting is specified on the plans, the pole, arm, and base plate shall be painted according to the provisions of Section 638.

714.03 Fabrication. The pole shall be constructed to the dimensions shown on the plans. The pole shaft shall have a continuous taper with only one vertical seam electrically welded and rolled smooth. A handhole of sufficient size to allow for internal wiring shall be provided near the pole base. A reinforcing frame for the handhole tapped for a grounding bolt shall be welded into the shaft a short distance from the base. A J-hook wire support shall be welded inside the shaft near the top of the pole.

A cast steel or plate anchor base of the size and shape shown on the plans shall be electrically welded to the bottom of the pole. The anchor base and welding thereto shall develop the full strength of the adjacent shaft.

The arm may be connected to the pole using clamp and gusset plates or flange and gusset plates. When using clamp plates, one rounded plate conforming to the curvature of the pole shall be welded to the mast arm and reinforced with gusset plates as required to develop sufficient strength. The back clamp plate shall be connected to the mast arm clamp plate with 4 bolts of sufficient size to develop adequate strength in the connection.

When using flange and gusset plates to connect the arm to the pole, adequate size plates shall be welded to the pole in the proper position. Another flange plate of suitable design and strength shall be welded to the end of the arm. The arm will then be connected to

the pole by 4 bolts of sufficient size to develop adequate strength in the connection.

Four anchor bolts with hex leveling nuts shall be provided with each pole. The anchor bolts shall be of the length shown on the plans and have an L-bend on the bottom and shall be threaded at the top.

Before installation, the Contractor shall furnish to the Engineer design details regarding this item. These details shall specify materials and shall include a certification prepared and/or approved by a Professional Engineer who is registered in any of the United States:

- That the design complies with the plans and specifications and meets or exceeds the standards found in AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals 4th Edition (2001)* with 2003 and 2006 interims.
- That the materials specified in the design meet or exceed the requirements of Subsection 714.02.

The Contractor shall also furnish a certification from the manufacturer or supplier that the traffic signal mast arm and pole were fabricated in compliance with the certified design and that the materials furnished comply with the specifications.

714.04 Construction Requirements. The Contractor shall contact the local utility companies to determine the location of underground utilities in the area where the foundations are to be located and shall be responsible for repairing, to the satisfaction of the utility company, any damaged utilities.

Excavation, backfill, compaction, and disposal of surplus materials shall be performed to the satisfaction of the Engineer. Compaction shall be accomplished to the extent necessary to prevent future settlement of the backfill. Disturbed surfaces shall be returned to the original condition.

Foundations for the traffic signal mast arm and pole shall be constructed in firm earth to the minimum size and depth shown on the plans. The location of foundations shall be as shown on the plans or as directed by the Engineer. Foundations shall be placed monolithically and have a 1" (25 mm) chamfer at the top.

Conduit, anchor bolts, and ground rods shall be placed in proper position and shall be held in place by means of a template until the concrete sets. Concrete shall be constructed according to Section 802. The exposed portion of the foundation shall be given a Class 2 finish. The area between the top of the foundation and the pole base shall be neatly grouted after the pole has been raked and secured in place. The pole shall not be erected upon the foundation for a minimum of 72 hours after placement of concrete.

Mast arm support poles shall be securely bolted to the foundation in a raked position employing galvanized leveling nuts.

Mast arm support poles shall be effectively grounded by means of a ground rod. The grounding wire shall be attached to the pole using a solderless steel bolt.

Subsequent to erection, any damaged galvanized coating or paint shall be repaired according to Subsection 807.88 or Section 638, as appropriate.

All holes in traffic signal mast arms and poles required for traffic signal cable, controller mountings, etc., shall be machine drilled.

714.05 Method of Measurement. Traffic Signal Mast Arm and Pole with Foundation will be measured by the unit.

714.06 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Traffic Signal Mast Arm and Pole With Foundation of the arm length specified, which price shall be full compensation for furnishing and installing the pole and arm; for excavation, backfill, compaction, and removal of surplus material; for furnishing and placing reinforcing steel and concrete; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Traffic Signal Mast Arm and Pole With Foundation (___') (___m)	Each

SECTION 715
TRAFFIC SIGNAL PEDESTAL POLE WITH FOUNDATION

715.01 Description. This item shall consist of furnishing and erecting steel traffic signal pedestal poles with foundations according to these specifications and to the dimensions and details and at the locations shown on the plans or as directed.

715.02 Materials. The following material requirements shall apply to poles and foundations.

(a) The poles shall be constructed of 4" (100 mm) standard steel pipe shaft complying with ASTM A 501 or A 53 Grade B. Galvanizing shall comply with AASHTO M 111, Thickness Grade 100.

(b) Anchor bolts shall comply with AASHTO M 314, Grade 55 (379), including Supplementary Requirement S1. All exposed portions of bolts shall be galvanized according to AASHTO M 232 or ASTM B 695, Class 40 or 50.

(c) Anchor Base Plates shall be AASHTO M 270 Grade 36 (250). Galvanizing shall comply with AASHTO M 111, Thickness Grade 100.

(d) Cast Anchor Base Plates shall be AASHTO M 103 Grade 65-35. Galvanizing shall comply with AASHTO M 232.

(e) Hex nuts shall comply with AASHTO M 292 Grade 2H or AASHTO M 291 Grade DH or DH3 (Grade 10S or 10S3). The thread series shall correspond with that of the bolt furnished. Washers shall comply with AASHTO M 293. Galvanizing shall comply with AASHTO M 232 or ASTM B 695, Class 40 or 50. Nuts shall be galvanized by the same process as that of the bolts.

(f) Concrete shall comply with Section 802 for Class S concrete. The Department will perform all acceptance sampling and testing at the frequencies shown for Contractor acceptance testing in Subsection 802.06. Reinforcing steel shall comply with Section 804 for Grade 40 steel.

(g) Ground rods shall be 5/8" (16 mm) diameter or greater Copperweld with ground wire and connections.

(h) When painting is specified on the plans, the pole and base plate shall be painted according to the provisions of Section 638.

715.03 Fabrication. The pole shall be constructed to the dimensions shown on the plans. A handhole of sufficient size to allow for internal wiring shall be provided near the pole base. A reinforcing frame for the handhole tapped for a grounding bolt shall be welded into the shaft a short distance from the base.

A cast steel or plate anchor base of the size and shape shown on the plans shall be electrically welded to the bottom of the pole. The anchor base and welding thereto shall develop the full strength of the adjacent shaft.

Four anchor bolts with hex nuts shall be provided with each pole. The anchor bolts shall be of the length shown on the plans and have an L-bend on the bottom and shall be threaded at the top.

Before installation, the Contractor shall furnish to the Engineer design details regarding this item. These details shall specify materials and shall include a certification prepared and/or approved by a Professional Engineer who is registered in any of the United States:

- That the design complies with the plans and specifications and meets or exceeds the standards found in AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals 4th Edition (2001)* with 2003 and 2006 interims.
- That the materials specified in the design meet or exceed the requirements of Subsection 715.02.

The Contractor shall also furnish a certification from the manufacturer or supplier that the traffic signal pedestal pole was fabricated in compliance with the certified design and that the materials furnished comply with the specifications.

715.04 Construction Requirements. The Contractor shall contact the local utility companies to determine the location of underground utilities in the area where the foundations are to be located and shall be responsible for repairing, to the satisfaction of the utility company, any damaged utilities.

Excavation, backfill, compaction, and disposal of surplus materials shall be performed to the satisfaction of the Engineer. Compaction shall be accomplished to the extent necessary to prevent future settlement of the backfill. Disturbed surfaces shall be returned to the original condition.

Foundations for the traffic signal pedestal pole shall be constructed in firm earth to the minimum size and depth shown on the plans. The location of foundations shall be as shown on the plans or as directed by the Engineer. Foundations shall be placed monolithically and have a 1" (25 mm) chamfer at the top.

Conduit, anchor bolts, and ground rods shall be placed in proper position and shall be held in place by means of a template until the concrete sets. Concrete shall be constructed according to Section 802. The exposed portion of the foundation shall be given a Class 2 finish. The area between the top of the foundation and the pole base shall be neatly grouted after installation. The pole shall not be erected upon the foundation for a minimum of 24 hours after placement of concrete.

The pedestal pole shall be securely bolted to the foundation in a perpendicular position, employing galvanized shims if necessary.

Poles shall be effectively grounded by means of a ground rod. Grounding wire shall be attached to the pole using a solderless steel bolt.

Subsequent to erection, any damaged galvanized coating or paint shall be repaired according to Subsection 807.88 or Section 638, as appropriate.

All holes in traffic signal pedestal poles required for traffic signal cable, controller mountings, etc., shall be machine drilled.

715.05 Method of Measurement. Traffic Signal Pedestal Poles with Foundation will be measured by the unit.

715.06 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Traffic Signal Pedestal Pole With Foundation, which price shall be full compensation for furnishing and installing the pole; for excavation, backfill, compaction, and removal of surplus material; for furnishing and placing reinforcing steel and concrete; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Traffic Signal Pedestal Pole With Foundation	Each

SECTION 716
TREATED WOOD POLE

716.01 Description. This item shall consist of furnishing and installing treated wood poles and accessories of the class and size called for at the locations shown on the plans, or as directed by the Engineer.

716.02 Materials. The poles shall be selected for straightness. All poles shall comply with AWPA Standard U1, Commodity Specification D, to the requirements of Use Category UC4B for pentachlorophenol or copper chromated arsenate treated poles. The Contractor shall furnish a certification that the poles furnished comply with AWPA Standard U1, Commodity Specification D, to the requirements of Use Category UC4BC1.

716.03 Construction Requirements. The Contractor shall contact the local utility companies to determine the location of underground utilities in the area where the poles are to be installed and shall be responsible for repairing, to the satisfaction of the utility company, any damaged utilities.

Guy wires shall be installed when shown on the plans.

Excavation, backfill, compaction, and disposal of surplus materials shall be accomplished to the satisfaction of the Engineer. Compaction shall be accomplished to the extent necessary to prevent future settlement of the backfill. Disturbed surfaces shall be restored to the original condition.

716.04 Method of Measurement. Treated Wood Poles will be measured by the unit.

716.05 Basis of Payment. Treated Wood Poles placed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Treated Wood Pole of the class and size specified, which price shall be full compensation for excavation, backfill, and compaction; for furnishing all materials, guy wires, fittings, and clamps; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Treated Wood Pole (Class__, ___ft. [___m])	Each

SECTION 717
TRAFFIC SIGNAL EQUIPMENT PERFORMANCE TEST

717.01 Description. This item shall consist of providing a 6 month guarantee and proving the soundness of all traffic signal equipment and related electrical components installed at each location according to these specifications and at locations shown on the plans or as directed.

The Contractor shall conduct a performance test, which shall consist of a continuous 30 day period of operation without a major malfunction. A major malfunction is considered to be any occurrence, other than a power failure beyond the Contractor's control, that renders the installation inoperative either momentarily or for a longer period. Lamp burnouts are not considered a major malfunction unless 2 or more bulbs in the same socket burn out within the 30 day period.

The Contractor shall obtain and assign to the Department transferable manufacturers' warranties or guarantees on all electrical and mechanical equipment, consistent with those provided as customary practice. The Contractor shall guarantee satisfactory in-service operation of the mechanical and electrical equipment and related components for a period of 6 months following completion of the 30 day performance test, at no cost to the Department.

Defective equipment or accessories shall be repaired or replaced according to applicable specifications and to the satisfaction of the Engineer, within a reasonable period of time during the 30 day performance test and the 6 month guarantee period.

717.02 Method of Measurement and Basis of Payment. Work completed and accepted under this item will not be measured and paid for directly but will be considered a part of the traffic signal equipment involved at each installation. Partial payments will be made as the various items of work are satisfactorily completed and accepted by the Engineer. Final acceptance and processing of the final estimate will be made after the 6 month guarantee period.

SECTION 718
REFLECTORIZED PAINT PAVEMENT MARKING

718.01 Description. This item shall consist of furnishing and placing reflectorized paint pavement markings, including words, arrows, and emblems, of the color and type specified, and the removal of pavement markings, all in accordance with these specifications and to the dimensions and at the locations shown on the plans or as directed.

The markings are to be placed under existing traffic conditions. The work shall meet the requirements of the MUTCD except as modified by these specifications.

In lieu of painted markings, the Contractor may substitute Permanent Pavement Marking Tape meeting the requirements of Section 720 for Type 2, 3, or 5, or Thermoplastic Pavement Marking meeting the requirements of Section 719. Payment will be made at the contract unit prices bid for painted markings.

718.02 Materials. The paint shall be a ready mixed white and yellow paint suitable for application on concrete and bituminous pavements. All paints used for this application shall be listed on the QPL. The manufacturer shall furnish a certification for each lot certifying that the materials supplied conform to all the requirements specified and stating that the material is formulated the same as the material tested for QPL listing. Random samples may be taken and tested by the Department. The paint shall be a waterborne acrylic emulsion polymer paint or a cold weather waterborne acrylic emulsion polymer paint.

The paint shall have the property of angular reflectivity and shall be suitable as a binding medium for glass beads placed on the surface of the wet paint in the amount of not less than 8 pounds per gallon (0.93 kg/L). It shall be homogeneous and well ground, shall not settle badly, and shall be readily broken up with a paddle to a smooth, uniform consistency. It shall be free from foreign matter and shall dry within the specified time to a tough serviceable film. The paint shall be properly strained during the final filling of containers and not more than 1% of coarse particles and skins shall be retained on a #325 (0.045 mm) sieve when tested according to ASTM D185.

All materials used in the manufacture of these paints shall meet the requirements herein specified. Minor ingredients not specifically covered will be left to the discretion of the manufacturer except that the finished product shall not be adversely affected. The suitability of raw materials from different sources for use in these paints will be the responsibility of the manufacturer. Reactive or unstable products causing excessive viscosity or container instability will be cause for rejection of the paint. Cold weather waterborne acrylic emulsion polymer paint does not have to meet the Raw Materials requirements of paragraph (b), Raw Materials for Vehicles (Waterborne), subparagraphs (1) and (2) of paragraph (c) Physical Requirements of the Finished Pavement (Waterborne) except for Grind, Laboratory Dry Time, and Dry Through, or the Waterborne Acrylic Emulsion Paint Formulation table requirements.

The paint shall conform, on a weight basis, to the composition requirements of the formulation as closely as accepted good paint practice will permit. No intentional variation will be permitted except for replacement of volatiles lost in processing. Recognized test procedures will be used by the Department to determine the composition of the finished paint.

Paint components shall conform to the following requirements:

(a) Raw Materials for Pigments (Waterborne)

(1) Rutile Titanium Dioxide shall comply with the latest revision of ASTM-D-476, Type II.

(2) Calcium Carbonate shall comply with the latest revision of the specification for Calcium Carbonate Pigments, ASTM D 1199, Type GC, Grade 1, with minimum of 95% Calcium Carbonate and Type PC, minimum 98% Calcium Carbonate.

(3) Yellow Iron Oxide shall comply with the latest revision of ASTM D768 and will only be allowed from Harcors (YLO-2288D) or OSO Iron Oxide (OSO440).

(4) Pigment Yellow 65 will only be allowed from Hoechst Celanese, Engelhard, or Sun Chemical.

(5) The pigments used for the pavement marking material compound shall not contain any compounds that will exceed the values listed in the Environmental Protection Agency Code of Federal Regulations (CFR) 40, Section 261.24, Table 1.

(b) Raw Materials for Vehicles (Waterborne)

(1) Acrylic Emulsion Polymer: The non-volatile portion of the vehicle shall be composed of a 100% acrylic polymer or 100% styrene acrylic polymer and shall not be less than 44.0% by weight. Acrylic emulsion polymer shall be Rohm and Haas E 3427, Dow DT 250NA, or equal as determined by the Division Engineer, Materials.

(2) Glycol: Propylene Glycol - ASTM D5164, or Ethylene Glycol - ASTM D2693.

(3) Water: Potable

(4) Miscellaneous Materials:

(a) Dispersant - Tamol 850, Colloids 226-35.
(b) Surfactant - Triton X405, Igepal CA407.
(c) Defoamer - Foamaster 111, Drew 493, Colloids 654.
(d) Hydroxy Ethyl Cellulose – Natrosol 250 HBR, Bermocoil E431FQ.
(e) Coalescent - Texanol.
(f) Preservative - Troy 192, Dowicil 75, Nuosept 101.

(c)Physical Requirements of the Finished Paint (Waterborne)

(1) Pigment Composition. Analysis of the extracted pigment shall conform to the following requirements:

	Percent by Weight	
	White	**Yellow**
Organic Yellow 65	---	Min. 7.5*
Titanium Dioxide	Min. 13.4	Min. 5.5
Calcium Carbonate	Max. 86	Max. 87
Yellow Iron Oxide	---	Min. 0.3

*****To be determined by x-ray fluorescence, color spectrophotometry, or any other method the Department may choose. This may be sent to an outside agency or organic pigment manufacturer. It also may include audit of the manufacturer's invoices, batch tickets, inventory or any other means determined by the Department.

(2) Physical Properties.

% Total Solids by weight, minimum	73
% Volume Solids, minimum	58

% Pigment by weight	49-54
% Vehicle by weight	46-51
% Non-volatile in Vehicle by weight, minimum	44
Weight per gallon, lbs.	±0.30 Theo.or ±0.10 by split weight
(per liter, kg)	(±0.04) Theo. or ±0.01 by split weight
Viscosity, 77°F (25°C), Krebs Units	83-98
Grind (Hegman Gage), minimum	3
Laboratory Dry Time, ASTM D 711, minutes, max.	10
pH, minimum	9.6
Dry Through	130 minutes, maximum*

*No more than 15 minutes longer than the specifiers reference paint film

(3) Color. The color after drying shall (for white) be a flat white, free from tint, furnishing good opacity and visibility under both daylight and artificial light. For yellow, the color shall closely match Color Chip 33538 of Federal Standard 595 and be ± 6% from the PR 1 chart central color when read over the black portion of a 2A Leneta Chart or equal.

(4) Flexibility and Adhesion. The paint shall adhere firmly and shall not show any evidence of cracking or flaking when a 15 mil (380 μm) wet thickness is tested according to AHTD Test Method 701.

(5) Water Resistance. The paint shall show no adhesion loss or blistering when a 15 mil (380 μm) wet film thickness is tested according to AHTD Test Method 701.

(6) Heat Stability. The paint shall show no coagulation, discoloration or change in consistency greater than 10 Kreb Units, when tested according to Federal Specification TT-P-1952B.

(7) Dilution Test. The paint shall be capable of dilution with water at all levels without curdling or precipitation such that the wet paint can be readily cleaned up with water only.

(8) Storage Stability. After 30 days storage in three-quarters filled, closed container, the paint shall show no caking that cannot be readily remixed to a smooth, homogeneous state, no skinning, livering, curdling, or hard settling. The viscosity shall not change more than 5 Kreb Units from the viscosity of the original sample.

(9) Contrast Ratio. The minimum contrast ratio shall be 0.96 when drawn down at a wet film thickness of 15 mils (380µm) on a 2A Leneta Chart or equal, air dried for 24 hours, and tested according to AHTD Test Method 701. Contrast Ratio = Black/White.

(10) Luminance Factor. The daylight luminance factor (Y%) of the white paint shall not be less than 84% and not less than 50% for yellow paint of a 15 mil (380 µm) wet film applied to a 2A Leneta Chart or equal. After drying 24 hours, measure the reflectance of the paint over the black portion of the chart using ASTM E 1347 with CIE illuminant D65 and the 1931 CIE 2° standard observer.

(11) Bleeding Ratio. The paint shall have a minimum bleeding ratio of 0.97 when tested according to Federal Specification TT-P1952B, except the asphalt saturated felt shall be Standard 15# roofing felt with evalution in accordance with ASTM E 1347. The paint shall not check or crack on asphalt saturated 15# felt indicating unsuitability for use on fresh asphalt overlays. Any checking or cracking on the felt or on fresh asphalt cores will be cause for rejection.

(12) Dry Through Time. The paint shall be applied to a non-absorbent substrate at a wet film thickness of 15 mils ± 1 mils (380 ± 25 µm) and placed in a humidity chamber controlled at 90 ± 5% R.H. and 72.5°F ± 2.5°F (22.5° ± 1.4°C). The dry through time shall be determined according to ASTM D 1640, except that the pressure exerted shall be the minimum needed to maintain contact with the thumb and film.

WATERBORNE ACRYLIC EMULSION PAINT FORMULATION

	WHITE		YELLOW	
	lbs. Per 100 gal.	**kg per 100 Liters**	**lbs. Per 100 gal.**	**kg per 100 Liters**
C.I. Pigment Yellow 65	--	--	50	6.0
Titanium Dioxide, Rutile, Type II	100	12.0	40	4.8
Yellow Iron Oxide	--	--	2	0.2
Calcium Carbonate, Type PC	150	18.0	125	15.0
Calcium Carbonate, Type GC	430	51.5	450	53.9
Hydroxy Ethyl Cellulose	0.5*	0.06*	0.3*	0.04*
Acrylic Emulsion, 50% Solids (E-3427 or DT 250NA)	541	64.8	540	64.7
Texanol	23	2.8	23	2.8
Defoamer	5	0.6	6	0.7
Dispersant	8	1.0	10	1.2
Surfactant	2	0.2	2	0.2
Preservative	1.5	0.18	1.5	0.18
Water	20	2.4	20	2.4
Ethylene Glycol or Propylene Glycol	25	3.0	25	3.0
TOTAL	1306	156.54	1294.8	155.12

*Hydroxy Ethyl Cellulose amount may be varied by up to 0.01 kg (0.1 pound) to adjust viscosity to desired range.

(g) Glass Beads. (1) General: The glass beads furnished shall be moisture resistant, free flowing, AASHTO M 247, Type 1 beads with a silane adhesion coating conforming to the specific test requirements herein. A written certification of compliance shall be furnished by the manufacturer for each batch furnished.

(2) Specific Requirements:

(a) Turn on UV light of intensity 7000 UM/CM (Fisher Scientific Model B-100-R) at least 30 minutes prior to test.

(b) Prepare a solution by weighing 0.2 grams of dansyl chloride and dissolving in 25 ml of acetone. This solution can be used for several tests during the day, but must be kept refrigerated in a closed dark container between uses. Make a fresh solution daily.

(c) Weigh 10 grams of beads and place on a filter paper in a Buchner funnel.

(d) Saturate the glass bead sample with dansyl chloride solution using an eyedropper.

(e) Place in a 140° F (60° C) oven for 15 minutes and then rinse off the excess reagent by pouring 100 ml of acetone over the beads in the funnel. Suction should be on during this step. All yellow color must be removed from the bead surface.

(f) Allow the beads to dry at room temperature for 5 - 10 minutes.

(g) Place glass beads on glass filter paper and inspect under UV light. Inspection must be in a dark room. A yellow-white fluorescence will be observed with properly adherence-coated beads. If no fluorescence is observed, test should be rerun using fresh solution of dansyl chloride.

718.03 Construction Requirements. Reflectorized paint shall be applied to clean, dry, and dirt-free surfaces. The paint shall be applied at a minimum wet film thickness of 15 mils (380 µm) (a minimum of 16.5 gallons per mile [40 L/km] of 4" [100 mm] line). Glass beads shall be placed on the surface of the wet paint in the amount of not less than 8 pounds per gallon (0.93 kg/L). The Contractor will be responsible for any necessary cleaning of surfaces before paint application.

Spotting the pavement for center line location on two-way roadways is required. It will be the responsibility of the Contractor to spot using a string line or chain so that spots are placed at intervals not exceeding 10' (3 m). The Department will establish the no passing zones if required. On one-way roadways spotting is required for the initial edge line or lane line placed. Edge lines and/or lane lines may be installed by referencing to center or lane lines. Edge lines shall not be broken for driveways.

The finished lines shall have well defined edges, shall be uniform in thickness, and shall be straight and true. No stripe shall be less than the specified width. Any corrections of variations in width or alignment of the stripes shall not be made abruptly. Lines that

cannot be corrected to meet these requirements shall be removed in accordance with Section 604 at the Contractor's expense.

Line removal as specified on the plans shall be performed in such a manner that no conflicting pavement marking will be left in place. Removal of the pavement marking by a means that will gouge the surface will not be permitted.

The Contractor shall use only workers experienced in installing paint markings.

718.04 Method of Measurement. **(a)** Reflectorized paint pavement markings will be measured by the linear foot (meter) of marking actually placed.

(b) Reflectorized paint pavement marking words and arrows will be measured by the unit.

(c) Reflectorized paint railroad emblems will be measured by the unit. Each unit shall consist of the R's, the X, the transverse lines and the stop line at the track.

(d) Removal of pavement markings of all types will be measured and paid for under Section 604.

718.05 Basis of Payment. (a) Reflectorized Paint Pavement Marking. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per linear foot (meter) for Reflectorized Paint Pavement Marking of the width specified, which price shall be full compensation for furnishing and installing markings; for surface preparation; and for all labor, equipment tools, and incidentals necessary to complete the work.

(b) Reflectorized Paint Pavement Marking (Words), (Arrows), and (Railroad Emblems). Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Reflectorized Paint Pavement Marking (Words), (Arrows), and (Railroad Emblem), which price shall be full compensation for furnishing and installing Words, Arrows, and Railroad Emblems; for surface preparation; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
Reflectorized Paint Pavement Marking White (___") (__mm)	Linear Foot (Meter)
Reflectorized Paint Pavement Marking Yellow (___") (__mm)	Linear Foot (Meter)
Reflectorized Paint Pavement Marking (Words)	Each
Reflectorized Paint Pavement Marking (Arrows)	Each
Reflectorized Paint Pavement Marking (Railroad Emblem)	Each

SECTION 719
THERMOPLASTIC PAVEMENT MARKING

719.01 Description. This item shall consist of furnishing and placing thermoplastic or heat-fused, preformed thermoplastic pavement markings, including words, arrows, and emblems, of the color and type specified, and the removal of pavement markings, all according to these specifications and in conformity with the dimensions and at the locations shown on the plans or as directed.

The markings are to be placed under existing traffic conditions. The work shall comply with the MUTCD except as modified by these specifications.

719.02 Materials. The material used shall be a product especially compounded for traffic markings and be listed on the Department's Qualified Products List. Each container shall be clearly and adequately marked to indicate the color, weight, batch or lot number, and type of material.

The material shall meet the requirements of AASHTO M 249 with the following exceptions on yellow materials:

719

Color Specifications							
Color Specification Limits – Daytime Initial							
Chromaticity Coordinates							
1		2		3		4	
x	y	x	y	x	y	x	y
0.499	0.466	0.545	0.455	0.518	0.432	0.485	0.454
Luminance Factor, Y(%)							
Minimum				Maximum			
40.0				60.0			

Initial daytime color determination will be made in accordance with AASHTO T 250. Values shall be evaluated on material without the drop-on beads.

Color Specifications Limits – Daytime Retained							
Chromaticity Coordinates							
1		2		3		4	
x	y	x	y	x	y	x	y
0.560	0.440	0.490	0.510	0.420	0.440	0.460	0.400

Retained daytime color limits shall conform to the specifications for a minimum of ninety days for construction pavement markings and one year for all other markings. Retained readings will be determined on a beaded surface in accordance with the requirements of ASTM E 2366.

Color Specifications Limits – Nighttime Initial with drop-on beads							
Chromaticity Coordinates							
1		2		3		4	
x	y	x	y	x	y	x	y
0.575	0.425	0.508	0.415	0.473	0.453	0.510	0.490

Initial nighttime color limits will be determined in accordance with the requirements of ASTM E 2367 on a beaded surface.

The pigments used for the pavement marking material compound shall not contain any compounds that will exceed the values listed in the Environmental Protection Agency Code of Federal Regulations (CFR) 40, Section 261.24, Table 1.

Heat-fused, pre-formed thermoplastic pavement marking material shall meet the requirements of AASHTO M 249 with the exception of the relevant differences due to the material being pre-formed.

The material shall not break down or deteriorate if held at the plastic temperature for a period of 4 hours nor by reason of 4 re-heatings to the plastic temperature. The temperature-viscosity characteristics of the thermoplastic material shall remain consistent and there shall be no obvious change in the color of the material.

The material shall not deteriorate by contact with sodium chloride, calcium chloride, or other chemical formations on the roadway or streets, or because of the oil contact on pavement material, or from oil droppings from traffic.

After application and proper drying time, material shall show no appreciable deformation nor discoloration under local traffic conditions and in air or road temperatures ranging from 0° F (-18° C) to 160° F (71° C). The material shall not smear or spread under normal traffic conditions at temperatures below 160° F (71° C).

Under this specification, the term "drying time" shall be defined as the minimum elapsed time after application when the pavement marking shall have and retain the characteristics required in the preceding paragraphs. In addition, the drying time shall be established by the minimum elapsed time after application when traffic will leave no impression or imprint on the applied marking. The drying time shall not exceed a characteristic straight-line curve, the limits of which are 2 minutes at 50° F (10° C) and 15 minutes at 90° F (32° C), measured at a maximum relative humidity of 70%.

The pavement markings shall maintain its original dimension and placement. The exposed surface shall be free of tack. Cold ductility of the material shall be such as to permit normal movement with the road surface without chipping or cracking. The material shall not be slippery when wet and it shall not lift from the pavement in freezing weather.

The marking shall have a uniform cross section. The density and character of the material shall be uniform throughout its thickness and shall be completely reflectorized both internally and externally.

The glass beads used for the drop-on application shall meet AASHTO M 247 with a Type I gradation and shall be suitably treated to resist moisture and retain free flow properties. Beads shall not be specially treated to enhance flotation.

719.03 Construction Requirements. The thermoplastic compound shall be screed or ribbon extruded to the pavement surface. Heat-fused, pre-formed pavement markings shall be fusible to asphalt or Portland cement concrete surfaces by means of the normal heat of a propane weed-burner type of torch or other heating device as recommended by the manufacturer.

The equipment used to apply the thermoplastic compound onto the pavement shall be suitably equipped for heating and controlling the flow of the material. The equipment shall be constructed to provide continuous mixing and agitation of the material. The conveying parts of the equipment, between the main material reservoir and applicator, shall be so constructed as to prevent accumulation and clogging. The equipment shall be constructed so that all mixing and conveying parts, up to and including the applicator, maintain the material at the plastic temperature. The thermoplastic material shall be dispensed at a temperature recommended by the manufacturer. The applicator shall include a cutoff device remotely controlled to provide clean, square stripe ends and to provide a method for applying skip lines.

The thermoplastic reservoir shall be insulated and equipped with an automatic thermostatic control to maintain the proper temperature of the material.

The thermoplastic machine shall comply with the requirements of the National Board of Fire Underwriters.

Beads applied to the surface of the completed stripe shall be applied by an automatic bead dispenser attached to the pavement marking equipment in such a manner that the beads are immediately dispensed upon the completed line. The bead dispenser shall be equipped with an automatic cutoff control, synchronized with the cutoff of the pavement marking equipment. The beads shall be automatically applied at a minimum uniform rate of 8 pounds (39 kg) of glass beads to every 100 square feet (100 sq m) of surface.

Heat-fused, pre-formed pavement markings shall be instantly highly reflective without the application of additional glass beads.

Thermoplastic markings shall not be applied to the pavement surface when the pavement surface temperature is less than 50° F (10° C) or when the pavement surface shows evidence of moisture.

On new concrete pavements where no pavement markings exist or on existing concrete or asphalt pavements where the existing pavement markings are paint or thermoplastic and do not conflict with the proposed pavement markings, blasting with water or sand or a combination thereof will be required to remove any curing compound, oxidized paint or thermoplastic, or dirt to ensure a good bond. This blasting is considered surface preparation. On newly constructed asphalt pavements any sand, grit, or other surface contaminants must be removed using compressed air and/or sweeping. Water blasting may be necessary to remove surface contaminants which cannot be removed by the use of compressed air and/or sweeping. This work is considered surface preparation.

Conflicting pavement markings that exist shall be removed by blasting with water and/or sand or by grinding. This blasting or grinding is considered pavement marking removal.

The thickness of thermoplastic markings above the roadway surface shall be 90 mils (2.3 mm) (a minimum of 1584 pounds per mile [446 kg/km] of 4" [100 mm] line). The thickness will be measured by a device supplied by the Contractor during the course of the project capable of measuring the thickness of the marking as installed on the pavement. The minimum thickness, as required above, will be measured in the center of the line when gauged by the equipment described above. The minimum thickness 1/2" (12 mm) from the edges shall not be less than 75% of the thickness required in the center. Maximum thickness of markings is 3/16" (5 mm).

Heat-fused, pre-formed pavement markings shall be supplied with a minimum average thickness of 90 mils (2.3 mm) before application on the roadway surface.

On concrete pavements, paint pavement markings according to Section 718 shall be applied as a primer for the thermoplastic markings, except where thermoplastic markings are to be applied over existing thermoplastic markings. Paint applied to concrete pavement solely as a primer will not be measured or paid for separately, but full compensation therefor will be considered included in the contract unit prices bid for the various items of

Thermoplastic Pavement Markings. A primer other than paint may be used when recommended by the thermoplastic manufacturer.

A primer is not required for asphalt pavements, but paint pavement markings complying with Section 718 may be used by the Contractor as a primer at no cost to the Department.

When temperature limitations prohibit placement of thermoplastic markings within the 3 or 14 day limit specified in Section 604, the Contractor shall place painted markings according to Section 718. Painted markings required due to temperature limitations will be measured and paid for under Section 604. In this case, the Contractor shall maintain the painted markings at no additional cost to the Department until the thermoplastic markings, including primer if required, are installed.

Spotting the pavement for center line location on two-way roadways is required. It will be the responsibility of the Contractor to spot using a string line or chain so that spots are placed at intervals not exceeding 10' (3 m). The Department will establish the no passing zones if required. On one-way roadways spotting is required for the initial edge line or lane line placed. Edge lines and/or lane lines may be installed by referencing to center or lane lines. Edge lines shall not be broken for driveways. The trace of the thermoplastic line shall be uniform.

The finished lines shall have well defined edges, shall be uniform in thickness, and shall be straight and true. No stripe shall be less than the specified width. Any corrections of variations in width or alignment of the stripes shall not be made abruptly. Lines that cannot be corrected to meet these requirements shall be removed in accordance with Section 604 at the Contractor's expense.

Line removal as specified on the plans shall be performed in such a manner that no conflicting pavement marking will be left in place. Removal of the pavement marking by a means that will gouge the surface will not be permitted.

The Contractor shall use only workers experienced in installing thermoplastic markings.

719.04 Method of Measurement. (a) Thermoplastic Pavement Markings will be measured by the linear foot (meter) of line of the width specified actually placed.

(b) Thermoplastic words and arrows will be measured by the unit.

(c) Thermoplastic railroad emblems will be measured by unit. One unit shall consist of both R's; the X; the transverse lines; and the stop line near the track.

(d) Sand or water blasting in surface preparation will not be paid for separately, but full compensation therefor will be considered included in the contract unit price bid for Thermoplastic Pavement Marking.

(e) Removal of pavement markings will be measured and paid for under Section 604.

(f) Thermoplastic bike emblems will be measured by the unit. One unit shall consist of the words “BIKE” and “ONLY”, and the diamond emblem as shown in the plans.

719.05 Basis of Payment. (a) Thermoplastic Pavement Markings. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per linear foot (meter) for Thermoplastic Pavement Markings of the width specified, which price shall be full compensation for furnishing and installing markings; for surface preparation; and for all labor, equipment, tools, furnishing thickness gauge, and incidentals necessary to complete the work.

(b) Thermoplastic Pavement Marking (Words), (Arrows), (Railroad Emblems), and (Bike Emblems). Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Thermoplastic Pavement Marking (Words), (Arrows), (Railroad Emblems), and (Bike Emblems) which price shall be full compensation for furnishing and installing Words, Arrows, Railroad Emblems; and Bike Emblems for surface preparation; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Thermoplastic Pavement Marking White (___") (___mm)	Linear Foot (Meter)
Thermoplastic Pavement Marking Yellow (___") (___mm)	Linear Foot (Meter)

Thermoplastic Pavement Marking (Words)	Each
Thermoplastic Pavement Marking (Arrows)	Each
Thermoplastic Pavement Marking (Railroad Emblems)	Each
Thermoplastic Pavement Marking (Bike Emblems)	Each

SECTION 720
PERMANENT PAVEMENT MARKING TAPE

720.01 Description. This item shall consist of furnishing and installing retroreflective preformed pavement markings (RPPM) according to these specifications and in conformity with the types, dimensions, and lines shown on the plans or as directed by the Engineer.

The markings are to be placed under local traffic conditions and nothing in this specification shall be construed as waiving this basic requirement. The work shall comply with the MUTCD.

The retroreflective preformed pavement markings (RPPM) shall be listed on the Department's Qualified Products List.

720.02 Materials. The RPPM shall be one of five types, of various compositions for various applications as specified.

Type 1 - Retroreflective preformed pavement marking film for preformed markings subjected to moderate traffic volumes.

Type 2 - Retroreflective pliant polymer preformed pavement marking film for preformed markings subjected to high traffic volumes and severe wear conditions.

Type 3 - Retroreflective pliant polymer preformed pavement marking tape for preformed markings subjected to extremely high traffic volumes and severe wear conditions.

Type 4 - Retroreflective pliant polymer preformed pavement marking tape (removable) for preformed markings shall meet the requirements of ASTM D 4592, Type I.

Type 5 - Retroreflective preformed pavement marking film for marking subjected to high traffic volumes and repeated shear action

from crossover or encroachment or from stop, start or turn movements.

(a) General. The preformed markings shall consist of white or yellow tape or film with pigments selected and blended to conform to standard highway colors through the expected life of the markings. Glass beads shall be incorporated to provide immediate and continuing retroreflection.

The size, quality and refractive index of the glass beads shall be such that the performance requirements for the markings shall be met. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched with a thumbnail.

The preformed markings shall be capable of adhering to asphalt concrete or portland cement by a pre-coated pressure sensitive adhesive. A primer may be used to precondition the pavement surface according to the manufacturer's recommendations. The preformed markings shall mold to pavement contours by the action of traffic. The pavement markings also shall be capable of being inlaid on new, dense graded asphalt concrete wearing courses during the paving operation according to the manufacturer's instructions. After application, the markings shall be immediately ready for traffic.

(b) Composition. Type 1 retroreflective preformed pavement marking film shall consist of glass beads embedded in a white or yellow film with a thin, flexible conformable backing that is pre-coated with a pressure sensitive adhesive. The film without adhesive shall have a minimum thickness of 0.012" (0.30 mm).

Type 2 retroreflective pliant polymer preformed pavement marking film shall consist of a mixture of high quality polymeric materials, pigments and glass beads distributed throughout its base cross-sectional area, with a reflective layer of beads bonded to the top surface. The film without adhesive shall have a minimum thickness of 0.060" (1.5 mm).

Type 3 retroreflective pliant polymer preformed marking tape shall consist of a mixture of high quality polymeric materials, pigments and glass beads distributed throughout its base cross-sectional area, with a reflective layer of ceramic beads embedded into the waffle-patterned surface. The tape without adhesive shall have a minimum thickness of 0.065" (1.65 mm) at the thickest

portion of the cross-section and a minimum of 0.020" (0.5 mm) at the thinnest portion of the cross-section.

Type 4 retroreflective pliant polymer preformed marking tape (removable) shall consist of a mixture of high quality polymeric materials and pigments. The tape shall be reinforced with a medium to facilitate removal and pre-coated with pressure sensitive adhesive.

Type 5 retroreflective preformed pavement marking film shall consist of a mixture of high quality polymeric materials, pigments and glass beads distributed throughout its base cross-sectional area, with a reflective layer of beads bonded to the top urethane wear surface. The film shall have a pre-coated pressure sensitive adhesive.

(c) Reflectance. The white and yellow films shall comply with ASTM D 4505 reflectivity with Type 1 meeting Reflectivity Level II, and Type 2, 3, and 5 complying with Reflectivity Level I. Type 3 tapes shall exhibit a minimum retained reflectance value at 1.05° observation and 88.76° entrance angle of 100 mcd/ft2/fc (mcd/m2/lux) for a period of 36 months from the date of installation regardless of daily traffic volumes, when used in longitudinal lines. Type 4 tape shall comply with the requirements of ASTM D 4592.
(d) Skid Resistance. The surface of the markings shall provide an initial minimum skid resistance value of 45 BPN when tested according to AASHTO T 278.

720.03 Construction Requirements. The placement of the RPPM shall comply with the manufacturer's recommendations.

For Type 1 marking the minimum air and pavement temperature shall be 45° F (7° C) and rising before installation is allowed.

For Types 2, 3, and 5 markings, the air temperature shall be a minimum of 60° F (16° C) and rising or a minimum road temperature of 70° F (21° C). For Type 4 removable markings, the air, tape, and pavement temperature shall be 50° F (10° C) and rising.

When temperature limitations prohibit placement of Type 1, 2, 3, or 5 markings within the 3 or 14 day limit specified in Section 604, the Contractor shall place painted markings according to Section 718. Painted markings required due to temperature limitations will be measured and paid for under Section 604. In this

case, the Contractor shall maintain the painted markings at no additional cost to the Department until the RPPM is installed.

The roadway surface shall be cleaned by the Contractor with high pressure air or by sweeping. The roadway shall then be marked where the pavement marking polymer is to be applied.

The polymer can then be applied by hand or with a manual or mechanical highway tape applicator designed for that purpose. Only butt splices will be allowed with no overlapping.

After application, firmly tamp the tape with a minimum 200 lbs. (90 kg) load or by slowly (2-3 mph [3-5 km/h]) driving over the tape with a vehicle tire. Do not twist the tamping device on the tape. The Contractor shall ensure that all edges are firmly adhered.

Spotting of the center line and lane line locations, if required, shall be the responsibility of the Contractor. Establishment of no passing zones, if required, will be done by the Department and will be completed at such time as the Contractor begins work. Edge lines shall not be broken for driveways. The trace of the line shall be uniform.

All conflicting existing markings shall be removed according to Section 604.

720.04 Method of Measurement. **(a)** Permanent Pavement Marking Tape will be measured by the linear foot (meter) of the color, width, and type specified.

(b) Permanent Pavement Marking Tape (Words) and (Arrows) will be measured by the unit.

(c) Permanent Pavement Marking Tape (Railroad Emblems) will be measured by the unit. One unit shall consist of both R's; the X; the transverse lines; and the stop line near the track.

Removal of permanent pavement markings will be measured and paid for under Section 604. Removal of Type 4 (Removable) Tape will not be paid for separately, but full compensation therefor will be considered included in the contract unit price bid for Permanent Pavement Marking Tape (Type 4).

720.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per linear foot (meter) for Permanent Pavement Marking

Tape of the color, width, and type specified, or per each for Permanent Pavement Marking Tape (Words), (Arrows), or (Railroad Emblems), of the type specified, which price shall be full compensation for furnishing and installing the markings, for removal of Type 4 (Removable) tape, and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Permanent Pavement Marking Tape (Color, Width, Type___)	Linear Foot (Meter)
Permanent Pavement Marking Tape (Words)(Type___)	Each
Permanent Pavement Marking Tape (Arrows)(Type___)	Each
Permanent Pavement Marking Tape (Railroad Emblems)(Type___)	Each

SECTION 721
RAISED PAVEMENT MARKER

721.01 Description. This item shall consist of furnishing and installing raised pavement markers according to these specifications and at the locations shown on the plans or as directed.

721.02 Materials. The markers shall conform to the shape and dimensions shown on the plans.

Pavement markers shall be of the type and color shown on the plans or as specified herein.

(a) Type of Markers. Pavement markers shall be one of the following types:

Type I - One-Way (Color) Reflective Markers
Type II - Two-Way (Color/Color) Reflective Markers

(b) Packaging and Storage. Pavement markers shall comply with the following packaging and storage requirements.

(1) Packaging. Each package shall be clearly marked as to the name of the manufacturer, type, color, quantity enclosed, lot number, and date of manufacture.

(2) Storage. Markers shall be stored indoors and shall be protected from any source of moisture both during shipment to the project site and at the project site. The markers shall be maintained at a temperature high enough to preclude moisture condensation, and, at the time of placement, both the markers and their containers shall be dry.

(c) Reflective Pavement Markers. Reflective pavement markers shall be one of the following types:

- Prismatic reflector type, consisting of methyl methacrylate (MM) or suitable compounded acrylonitrile butadiene styrene (ABS) shell filled with a mixture of an inert thermosetting compound and filler material. The exterior surface of the shell shall be smooth and contain one or two methyl methacrylate prismatic reflector faces with thin, untempered glass bonded to the faces to provide an extremely hard and durable abrasion-resistant surface. The glass is not required on the red faces of two-way (Clear/Red) reflective markers. The infrared curves of the compounded MM or ABS shells shall match approved curves on file in the Materials Division.
- High performance microprismatic lens type, consisting of a polycarbonate lens with independent lens cells and a ceramer lens coating. The marker shall consist of hermetically sealed components in a fiber reinforced polycarbonate body with finger grip indentations for ease of handling.

The base of the marker shall be flat (the deviation from a flat surface shall not exceed 0.05" [1.3 mm]), rough textured, and free from gloss or substances that may reduce its bond to the adhesive.

Raised pavement markers shall meet the requirements of ASTM D 4280.

(d) Adhesives.

(1) Epoxy Adhesives. The epoxy adhesives shall comply with all the requirements of either Type I, Rapid Setting, High

Viscosity Epoxy Adhesive or Type II, Standard Setting, High Viscosity Epoxy Adhesive as specified in AASHTO M 237.

(2) Bituminous Adhesive for Pavement Markers. Bituminous adhesive shall be an asphalt material with a homogeneously mixed filler formulated primarily for use in bonding pavement markers to Portland cement concrete and asphalt concrete. The adhesive must be heated to a liquid state for application.

The epoxy adhesive and/or the bituminous adhesive shall be listed on the QPL.

721.03 Construction Requirements. Existing raised pavement markers shall be removed prior to the placement of any overlay or seal course. On pavements that are not to be overlaid or sealed, existing raised pavement markers which are damaged or which conflict with the new markers shall be removed as directed by the Engineer. Removal of existing pavement markings will not be paid for separately but will be considered subsidiary to other items of the work.

The surface to which the marker is to be bonded shall be free of dirt, curing compound, grease, oil, moisture, paint, and any other material that would adversely affect the bond of the adhesive. The adhesive shall be placed uniformly on the surface or on the bottom of the marker in a quantity sufficient to result in complete coverage of the area of contact of the marker with no voids present and with a slight excess after the marker has been pressed into place. Markers utilizing epoxy shall be placed in position and pressure applied until firm contact is made with the pavement. Markers with bituminous adhesive shall have a minimum adhesive pad thickness of 3/32" (2.4 mm) after installation. Viscosity of the bituminous material shall be such that flow about the periphery of the marker does not exceed 1½" (38 mm). Excess epoxy adhesive around the edge of the marker, excess adhesive on the pavement, and adhesive on the exposed surfaces of the markers, shall be immediately removed using a solvent and procedure recommended by the manufacturer of the markers. No other solvent shall be used. The marker shall be protected against impact until the adhesive has sufficiently set to resist movement.

Epoxy adhesive requires that the mixing operation and placing of the markers be performed rapidly. Just before use, components A and B shall be mixed in a 1:1 ratio by volume. When automatic proportioning and mixing machines are used, the temperature of the components shall be maintained by indirect heating or cooling, if required, for the adhesive to meter, mix, and extrude properly. The maximum temperature shall be such that after proper mixing, there shall be no excess flow of adhesive from under the marker other than that previously specified.

When hand mixing the Standard Set Type adhesive, not more than 1 quart (1 liter) shall be mixed at one time, and the markers shall be aligned and pressed into place within 5 minutes after mixing operations are started. Any mixed batch that becomes so viscous that the adhesive cannot be readily extruded from under the marker on application of slight pressure shall not be used.

Rapid Set Type adhesive shall not be mixed by hand. This adhesive shall be mixed by a 2 component type automatic mixing and extrusion apparatus.

When machine mixing the Standard Set Type adhesive or the Rapid Set Type adhesive, the markers shall be placed within 60 seconds after the adhesive has been mixed and extruded and no further movement of the marker will be allowed. In addition, no more than 90 seconds shall be permitted between the time the adhesive is pumped into the mixing head and the time this adhesive is in place on the roadway and not subject to further movement. The mixed adhesive shall not remain in the mixing head for more than 45 seconds. Adhesive remaining in the mixing head longer than this period shall be wasted before resuming the operation.

Automatic mixing equipment for the epoxy adhesive shall use positive displacement pumps and shall properly meter the 2 components in the specified ratio, ± 5% by volume of either component. At the beginning of each day, and at any other time ordered by the Engineer, the ratio shall be checked by the Contractor in the presence of the Engineer. This check shall be made by disconnecting the mixing heads, or using suitable bypass valves, and filling 2 suitable containers with the unmixed components. The mixing head shall properly mix the 2 components so that there is no trace of black or white streaks in the mixed material.

The Standard Set Type adhesive shall not be used when either the pavement or the air temperature is less than 50° F (10° C). The Rapid Set Type adhesive shall not be used when either the pavement or air temperature is less than 30° F (-1° C). No markers shall be installed if the relative humidity of the air is greater than 80% or if the pavement surface is not dry.

Voids in a cured, undisturbed sample of the mixed adhesive obtained from the extrusion nozzle shall not exceed 4%.

The Bituminous Type adhesive shall require the use of a melting apparatus. The melting apparatus shall incorporate a means of mixing the material before and during installation to assure homogeneity. Diffuse heat distortion (diffuse plate) shall be used to prevent overheating the material. A dispensing nozzle shall be utilized that has an independent way of heating the material to provide regulated control over output. The working temperature shall be from 400° F to 450° F (204° C to 232° C). The Bituminous adhesive shall not be used when either the pavement or air temperature is less than 32° F (0° C). The pavement markers can only be installed on a dry pavement surface.

Reflective markers shall be placed in such manner that the reflective face of the marker is perpendicular to a line parallel to the roadway centerline.

No pavement markers shall be placed over longitudinal or transverse joints of the pavement surface or over pavement cracks.

721.04 Method of Measurement. Raised Pavement Markers will be measured by the unit complete in place.

721.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid each for Raised Pavement Markers of the type specified, which price shall be full compensation for furnishing and installing Raised Pavement Markers; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Raised Pavement Markers (Type___)	Each

SECTION 722 VACANT

SECTION 723
GENERAL REQUIREMENTS FOR SIGNS

723.01 Description. These requirements consist of furnishing and installing highway signs, complete with posts, supports, and concrete bases, where required, according to these specifications and to the dimensions and details and at the locations shown on the plans or as directed.

723.02 Materials and Fabrication. (a) General. Signs shall comply with the requirements of the MUTCD, FHWA *Standard Highway Signs*, and *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects.*

All colors for signs shall match the colors specified in the MUTCD. The color and size of letters, symbols, borders, and background on signs shall be as specified on the plans.

Signs shall be made of aluminum and shall be reflectorized.

(b) Sign Panels. Standard signs shall consist of a single sheet of aluminum alloy (ASTM B 209, Alloy 5052 H38) without stiffeners on the back. Minimum sign blank thickness shall be 0.100" (2.5 mm) for a sign size of 5 square feet (0.5 sq m) or less; 0.125" (3.2 mm) for a sign size greater than 5 square feet (0.5 sq m); or 0.080" (2.0 mm) if so noted on the plans. Sign blanks shall be flat and straight and within commercial tolerances established by the aluminum industry.

Guide signs shall be fabricated using either one piece extruded panels, extrusheet welded panels, or extrusheet taped panels. The Contractor may use either type of panel fabrication but shall use the same type for all guide signs on the project.

The one piece extruded panels shall be fabricated of aluminum alloy (ASTM B 221, Alloy 6063 T6). The extrusheet welded panels shall be fabricated of sections of extruded aluminum alloy stiffeners (ASTM B 221, Alloy 6063 T6) welded to flat sheet aluminum alloy (ASTM B 209, Alloy 3003 H18) approximately 9" (230 mm) apart with spot welds at 4" (100 mm) centers as shown on the plans.

723

The extrusheet taped panels shall be fabricated of sections of extruded aluminum alloy stiffeners (ASTM B 221, Alloy 6063T6) adhered to flat sheet aluminum alloy (ASTM B 209, Alloy 3003H18) with double coated, acrylic foam tape.

Extruded panel and extrusheet signs shall consist of sign panels; stringers or horizontal supporting members; necessary fasteners for assembling the units; reflective materials; letters; numerals; symbols; and border. All extrusions and fasteners shall be applied without causing objectionable projections on the sign face.

The one piece extruded aluminum panels shall be a minimum of 12" (300 mm) in width except one 6" (150 mm) panel may be used per sign face when necessary to construct the sign as shown on the plans.

The extrusheet sign panel sections shall be either 24" or 36" (610 mm or 910 mm) in width with the following exceptions:

- If the total height of the sign face is not a multiple of 24" (610 mm) and the remaining increment is greater than 6" (150 mm), the bottom panel shall be the width of that increment with the remainder of the sign face in 24" and/or 36" (610 mm and/or 910 mm) panels.
- If the total height of the sign face is not a multiple of 24" (610 mm) and the remaining increment is 6" (150 mm), the bottom panel shall be 24" (610 mm) in width with the remainder of the sign face in 24" and/or 36" (610 mm and/or 910 mm) panels.
- Signs 2'-6" (750 mm) in height shall be constructed of one 2'-6" (750 mm) panel or one 18" (450 mm) and one 12" (300 mm) panel.

All extruded and extrusheet panels shall be bolted together at every other hole (every 24" [610 mm]) with the faces and ends in alignment.

Single sheet, extruded, and extrusheet panels to which reflective sheeting is to be applied shall be degreased, etched, and alodized.

Degreasing shall be done by the vapor method or alkaline method. Vapor degreasing shall be accomplished by total immersion of the sign panels in a saturated vapor of trichloroethylene or perchloroethylene. Alkaline degreasing shall be

accomplished by immersion of the sign panels in a tank containing alkaline solutions, controlled and titrated to the solution manufacturer's specification. Immersion time shall depend upon the amount of soil present and the gage of the metal. Trade mark printing shall be removed with lacquer thinner or by a controlled alkaline cleaning system.

Etching shall be done by the acid method or the alkaline method. Acid etch shall be done by immersion in a 6% to 8% phosphoric acid solution at 100° F (38° C) for a minimum of 3 minutes, then thoroughly rinsing with cold water, followed by a hot water tank rinse of 1 minute in water heated to 180° F (82° C). Alkaline etch shall be done by etching the precleaned surface in an alkaline etching material that is controlled by titration, using the time, temperature, and concentration specified by the solution manufacturer, then thoroughly rinsing. Remove smut with an acidic, chromium compound type solution as specified by the solution manufacturer, then rinse thoroughly.

The sign panels shall be treated by the alodizing process to uniformly provide a chemically formed light and tight amorphous coating that becomes an integral part of the aluminum alloy. This process shall be accomplished according to the recommendation of the manufacturer of the coating.

All fabrication, including cutting and punching of holes, excluding holes for demountable letters, numerals, symbols, and borders, shall be completed before metal degreasing, etching, alodizing, and the application of retroreflective sheeting.

Sign panels shall be free of buckles, warp, dents, cockles, burrs, and defects resulting from fabrication. The surface of all sign panels shall be flat.

The Contractor shall submit a Certified Test Report to the Engineer covering the sign panels.

(c) Retroreflective Sheeting. The retroreflective sheeting for signs shall comply with ASTM D 4956 for Type III, IV, VIII, or IX Retroreflective Sheeting, except that Type VIII or IX Retroreflective Sheeting shall be used on all delineators. All retroreflective sheeting shall have either Class 1 or Class 2 backing.

Retroreflective sheeting shall be applied to properly treated sign panels with mechanical equipment in a manner specified by the sheeting manufacturer. Sign faces comprising two or more pieces or panels of retroreflective sheeting must be carefully matched for color at the time of sign fabrication to provide uniform appearance and brilliance both day and night. Alternate successive width sections of either sheeting or panels must be reversed and consecutive to ensure that corresponding edges of retroreflective sheeting lie adjacent on the sign. Non-conformance may result in non-uniform shading and an undesirable contrast between adjacent widths of applied sheeting that will not be acceptable.

At splices, sheeting shall be overlapped no less than 3/16" (5 mm). Sheeting applied to a welded panel shall be trimmed flush with the edge of the panel.

(d) Legend. All legend, which includes letters, numerals, symbols, arrows, and border, shall have a regular outline, be clean cut and sharp, and shall have a continuous stroke and border without ragged or torn edges.

All legend on guide signs shall be of the size shown on the plans. Legend on standard signs shall comply with the latest revision of FHWA *Standard Highway Signs*.

Legend on guide signs on main lanes shall be demountable. Legend on guide signs on cross streets and ramps shall be direct applied. Legend on standard signs shall be silk screened except as noted on plans.

All demountable legend shall be of the same manufacturer. The sign area outside the corner radius shall not be trimmed to match the border radius.

(1) Direct Applied Legend. Unless otherwise shown, the legend and other features of the sign message shall be cut from the same Type sheeting as the sign face and shall have a Class 1 backing.

(2) Demountable Legend. Unless otherwise shown, the legend and other features of the sign message shall be cut from the same Type retroreflective sheeting as the sign face and applied to flat aluminum frames by a mechanical applicator process.

Frames for border strips, corners, shields, and legend shall be fabricated from 0.063" (1.6 mm) sheet aluminum complying with the requirements of ASTM B209, Alloy 5052-H38. Mounting holes shall be provided with the frames to permit the use of screws, bolts, rivets, or other fasteners of stainless steel, galvanized steel, or aluminum to fasten the frames to the sign face, subject to the condition that dissimilar metals shall be insulated to prevent corrosion.

The aluminum frames shall comply with Subsection 723.02(b).

All border material shall be secured from the same company that furnishes the cutout letters, numerals, etc., and shall be mounted in the same manner as the cutout letters.

(3) Silk Screen Process. The letters, numerals, arrows, symbols, border, and other features shall be produced on retroreflective sheeting of the sign field by a silk screen process approved by the Engineer. Sign messages and borders of a color darker than the sign field shall be applied to the sheeting by direct process. Sign messages and borders of a color lighter than the sign field shall be produced by the reverse process in which message and border are outlined by applying darker transparent color to the sheeting of the sign field.

Transparent colors, inks, and paints used in the silk screen process shall be of the type and quality recommended by the manufacturer of the reflective sheeting and shall conform to red, blue, yellow, and green colors approved by the FHWA and as shown in the MUTCD and FHWA *Standard Highway Signs*.

723.03 Shop Drawings. The Contractor shall submit, for the approval of the Engineer, prints of shop drawings in duplicate showing arrangements and spacing of all letters, symbols, and borders for each type of sign (with the exception of standard signs); the support to be used with each different type of sign panel (other than standard signs); the proposed method of attaching signs to the supports on signs not detailed on the plans; and the arrangement and width of panels on guide signs. The Contractor shall be responsible for the correctness of the drawings, even though the drawings may have been approved by the Engineer.

723.04 Construction Requirements. Signs shall be erected at the specified location, plumb, and to the specified vertical and horizontal clearances.

Roadside directional signs shall be erected at a minimum height of 7' (2 m) above the pavement edge, measured to the bottom of the sign. If a secondary sign is mounted below the primary sign, the primary sign shall be erected a minimum of 8' (2.4 m) above the pavement edge and the secondary sign a minimum of 5' (1.5 m) above the pavement edge. Route markers, warning signs, and regulatory signs shall be erected a minimum height of 6' (1.8 m) above the pavement edge. All heights measured to the bottom of the sign.

The minimum horizontal clearance to any ground mounted sign shall be 2' (0.6 m) beyond the edge of the roadway shoulder or unmountable curb face. Where there is a mountable curb, the horizontal clearance shall be established by the Engineer.

Signs shall normally be erected so that the sign face is vertical and at 93° away from the center of the lane that the sign serves and away from the direction of travel. Where lanes divide, or on curves, sign faces shall be oriented so as to be most effective both day and night, and to avoid the possibility of specular reflection.

Field drilling of holes in any part of the sign support structure shall be done only when specified on the plans or as directed by the Engineer.

After sign installation is complete, the signs will be inspected at night by the Engineer. If specular reflection is apparent on any sign, its position shall be adjusted by the Contractor to eliminate this condition.

723.05 Method of Measurement and Basis of Payment. Work completed and accepted under this item will not be measured and paid for directly but will be considered a part of the various applicable sign items in the Contract.

SECTION 724
OVERHEAD, BRIDGE MOUNTED, AND CANTILEVER SIGN STRUCTURES

724.01 Description. This item shall consist of furnishing, fabricating, and installing overhead sign structures with sign, luminaire supports when specified, and concrete foundations, according to these specifications, and to the dimensions and details and at the locations shown on the plans or as directed.

724.02 Materials. Materials for sign supports shall consist of aluminum alloy except as otherwise specified.

Aluminum sign support members shall comply with the following specifications for aluminum alloy:

Extrusions-Rods, Bars, and Shapes:	ASTM B 221, 6061-T6
Rolled Shapes:	ASTM B 308, 6061-T6
Sheet and Plate:	ASTM B 209, 6061-T6
Pipe:	ASTM B 241, 6061-T6
Extruded Tubing:	ASTM B 221, 6061-T6
Chord and Post Caps:	Sand Castings: ASTM B 26, 356-T6, or Plate: ASTM B 209, 6061-T6
Bolts:	ASTM B 211, 2024-T4
Nuts:	ASTM B 211, 6061-T6, or 6262-T9
Locknuts-Approved type:	ASTM B 211, 2017-T4
Washers:	ASTM B 209, Alclad 2024-T4
Panel Clips, Fittings:	Permanent Mold Castings ASTM B 108, A356-T61
Splice Flanges Welded:	ASTM B 209, 6061-T6
Welding Rods, Electrodes:	ER4043 or ER5556, AWS A5.10 Consumable Electrode Type

For aluminum sign supports, stainless steel bolts complying with ASTM A 193, Grade B8, Class 2, and strain hardened to a maximum 33 Hardness Rockwell C, may be used in lieu of aluminum alloy. Anchor Bolts, U-bolts and flange splice bolts shall comply with ASTM A 193, Grade B8, Grade B8N, or Grade B8C, Class 2, and strain hardened to a maximum 33 Hardness Rockwell C. Nuts for stainless steel bolts shall comply with ASTM A 194, Heavy Hex, Grade 8A, 8CA, 8MA, 8TA, 8FA, 8PA, 8NA, 8MNA, 8RA, 8SA, 8LNA, 8MLNA, or 8MLCuNA.

A chromate sealed anodized coating at least 0.0002" (0.005 mm) thick shall be applied to all finished aluminum bolts and nuts.

Aluminum alloy surfaces contacting concrete shall be thoroughly coated with an aluminum impregnated asphalt paint approved by the Engineer and allowed to dry before installation.

Concrete for footings shall comply with Section 802 for Class S concrete. The Department will perform all acceptance sampling and testing at the frequencies shown for Contractor acceptance testing in Subsection 802.06. Reinforcing steel shall comply with Section 804 for Grade 60.

724.03 Commercial Alternates. Subject to the approval of the Engineer and in conformance with the requirements specified herein, the Contractor may supply sign support structures as manufactured by a commercial sign structures manufacturer in place of the supports detailed on the plans.

If the Contractor elects to use a commercial product, a complete set of design calculations by a Registered Professional Engineer, a certification by the Professional Engineer that the design conforms to the requirements specified herein and as shown on the plans, and general details or pictures of the proposed type of structure shall be submitted to the Bridge Engineer for approval before submitting shop details.

In general, the commercial product shall be a truss type structure that will have an appearance similar to the design shown on the plans. The members may be round pipes or other structural shapes.

Sign supporting structures shall be designed for sufficient strength and stiffness to withstand a basic wind pressure of 25 pounds per square foot (1.2 kPa) on flat surfaces, according to the

current AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

Materials, construction methods, and inspection shall comply with this specification. If the fabricator elects to use materials of a different strength than that shown in this specification, this information shall be included in the request for approval of the commercial product.

724.04 Shop Drawings. Shop drawings, in duplicate, shall be submitted to the Bridge Engineer for approval before fabrication begins. The Contractor shall be responsible for the accuracy of the drawings, even though the drawings may have been approved by the Engineer.

724.05 Fabrication Requirements. Overhead, Bridge Mounted, and Cantilever Sign Structure bracing members shall be cut and trimmed for proper fit and shall be welded in correct position to chord or post members to form the specified structural section. Each assembly shall be checked for alignment, correct shape, and sound welds at the fabricating plant before shipment. The fabricator shall certify that each complete structure is free of misfits or structural deficiencies before shipment.

Visual inspection of all welds shall be made and any weld found to be defective shall be repaired only by rewelding. Inspection of all welds shall include, in addition to the visual inspection, an examination of certificates of prequalification of the welders who are performing the work and an inspection of welding equipment and procedure. In addition to visual inspection, the Department may require inspection by the red dye penetrant method for all the connecting welds between sign columns and base plates, including the connecting plate welds, when the column wall thickness is greater than 3/8" (10 mm). A report covering such inspection by the inspection agency, including a list of any defective welds that will require repairing, and certificates of prequalification of welding operators, shall be submitted to the Engineer of Materials. Any weld inspections and reports will be at the Department's expense, except that the Contractor shall make welded members accessible for inspection at no cost to the Department.

The method of qualifications and welding for aluminum alloy shall comply with the method described in the AWS Structural Welding Code - Aluminum D1.2.

The Contractor shall certify in writing that the welding and fabrication of the structures comply with the governing specifications.

724.06 Construction Requirements. Excavation, backfill, compaction, and disposal of surplus materials shall be performed according to Section 801. Compaction shall be accomplished to the extent necessary to prevent future settlement of the backfill. Disturbed surfaces shall be returned to their original condition.

The applicable provisions of Sections 802 and 804 shall govern the construction and installation of concrete and reinforcing steel.

Bridge mounted sign structures shall be attached in such a manner as to prevent damage to the bridge. Any resulting damage to the existing bridge shall be repaired as directed by the Engineer at no cost to the Department.

Field welding will not be permitted except upon approval in writing by the Engineer.

All sign supports shall provide a minimum vertical and horizontal clearance as shown on the plans. To insure proper clearances, dimensions of the structure that affect clearances shall be verified by the Contractor by field measurements before fabrication begins.

Sign supports shall be erected so that the sign face is plumb and at right angles to the road unless otherwise directed by the Engineer.

724.07 Method of Measurement. Overhead, Bridge Mounted, and Cantilever Sign Structures will be measured by the unit, including foundations, complete in place. One unit consists of the structure and all Z-bars, brackets, bolts, washers, nuts, and other hardware necessary to complete the installation and mount the sign(s). The fabrication and installation of the signs will be measured and paid for under Section 725 or 726.

724.08 Basis of Payment. Overhead, Bridge Mounted, and Cantilever Sign Structures completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Overhead Sign Structure, Bridge Mounted Sign Structure, or Cantilever Sign Structure of the structure designation specified,

which price shall be full compensation for furnishing, fabricating, and installing the structure including sign framing, supporting structures, and concrete foundations; for excavation, backfill, compaction, removal and disposal of surplus materials, and replacement of existing surfaces; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Overhead Sign Structure (___)	Each
Bridge Mounted Sign Structure (___)	Each
Cantilever Sign Structure (___)	Each

SECTION 725
GUIDE SIGN

725.01 Description. This item shall consist of furnishing and installing a Guide Sign on the sign support assembly according to these specifications and to the dimensions and details and at the locations shown on the plans or as directed.

725.02 Materials. The sign shall be fabricated of aluminum and reflective sheeting as described in Section 723.

725.03 Construction Requirements. The sign shall be securely installed at the correct location and set at the specified vertical and horizontal clearances.

Signs shall not be erected until the proposed sign layout, approximate location, and method of mounting have been approved by the Engineer.

725.04 Method of Measurement. Guide signs will be measured by the square foot (square meter) of sign area. Measurements will consist only of the face of the sign to the nearest 0.10 square foot (0.01 sq m) of area. No deduction will be made for corner radii or mounting holes.

Separate measurement will be made for the specified sign support.

All fabrication, installation, surface treatment, testing, and other items required under Section 723 shall be considered as part of this specification.

725.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per square foot (square meter) bid for Guide Sign - Roadside Mounted or Guide Sign - Overhead Mounted of the type specified, which price shall be full compensation for furnishing, fabricating, and erecting the signs; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Guide Sign - Roadside Mounted (___)	Square Foot (Square Meter)
Guide Sign - Overhead Mounted (___)	Square Foot (Square Meter)

SECTION 726
STANDARD SIGN

726.01 Description. This item shall consist of furnishing and installing Route Markers and Components, Regulatory Signs, and Warning Signs on the support assembly according to these specifications and to the dimensions and details and at the locations shown on the plans or as directed.

726.02 Materials. The sign shall be fabricated of aluminum and reflective sheeting as described in Section 723.

726.03 Construction Requirements. The sign shall be securely installed at the correct location and set at the specified vertical and horizontal clearance.

Signs shall not be erected until the proposed sign layout, approximate location, and method of mounting have been approved by the Engineer.

726.04 Method of Measurement. Route markers and components, regulatory signs, and warning signs will be measured by the square foot (square meter) of sign area. Measurements will

consist only of the face of the sign to the nearest 0.10 square foot (0.01 sq m) of area. No deduction in area will be made for corner radii or mounting holes.

The area of octagonal signs, pentagonal signs, U.S. Shields, and Interstate Shields will be computed as the area of the circumscribing square. The area of triangular signs will be computed as the area of the triangle. The area of circular signs will be computed as the area of the circle.

Separate measurement will be made for the specified sign supports.

All fabrication, installation, surface treatment, testing, and other items required under Section 723 shall be considered as part of this specification.

726.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per square foot (square meter) for Standard Sign, which price shall be full compensation for furnishing, fabricating, and erecting the sign; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Standard Sign	Square Foot (Square Meter)

SECTION 727
EXIT NUMBER PANEL

727.01 Description. This item shall consist of furnishing and installing an exit number panel with all necessary special framing required to be attached to a guide sign according to these specifications and to the dimensions and details and at the locations shown on the plans or as directed.

727.02 Materials. The sign shall be fabricated of aluminum and reflective sheeting as described in Section 723. Angles and Z bars used for installation shall be aluminum alloy 6061-T6,

ASTM B 221. Panel Clips and Fittings shall be Permanent Mold Castings ASTM A 356, or B 108.

727.03 Construction Requirements. The sign shall be securely installed at the correct location and set at the specified vertical and horizontal clearances.

727.04 Method of Measurement. Exit Number Panels will be measured by the square foot (square meter) of sign area, which measurement will consist of the face of the sign to the nearest 0.10 square foot (0.01 sq m) of area. No deduction in area will be made for corner radii or mounting holes.

All fabrication, installation, surface treatment, testing, and other items required under Section 723 shall be considered as part of this specification.

727.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per square foot (square meter) for Exit Number Panel of the type specified, which price shall be full compensation for furnishing, fabricating, and erecting the sign including Z-bars, angles, and hardware necessary for proper mounting; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work. Z-bars, angles, and hardware necessary for mounting will not be paid for separately, but full compensation therefor will be considered included in the contract unit price bid for Exit Number Panel (Type__).

Payment will be made under:

Pay Item	**Pay Unit**
Exit Number Panel (Type___)	Square Foot (Square Meter)

SECTION 728
DELINEATORS

728.01 Description. This item shall consist of furnishing and installing galvanized steel posts with delineators according to these specifications and to the dimensions and details and at the locations shown on the plans or as directed.

728.02 Materials. Delineators shall consist of white, yellow, or red reflectors made of adhesive coated Type VIII or Type IX reflective sheeting permanently adhered to a sheet of aluminum 0.080" (2.0 mm) thick and complying with Section 723.

Steel posts for roadside installation shall be made of a U-section channel, manufactured from re-rolled rail steel or equivalent, weighing not less than 2 pounds per foot (3 kg/m). The steel shall comply with the mechanical requirements of ASTM A 499, Grade 60, and the chemical requirements of ASTM A 1 for rails having a nominal weight of 90 pounds per yard (45 kg/m) or more. These chemical requirements shall include the following modified limitations:

Carbon	0.67 - 0.89%
Manganese	0.70 - 1.00%
Silicon	0.10 - 0.25%

The Contractor shall submit to the Engineer of Materials mill test reports showing chemical analysis and physical tests.

The post shall be punched or drilled with 3/8" (10 mm) holes on 1" (25 mm) centers for the full length of the post.

Steel posts for bridge rail installation shall be a 1" x 1" x 3/16" (25 mm x 25 mm x 4.76 mm) angle weighing 1.61 pounds per foot (2.4 kg/m), and manufactured from AASHTO M 270, Grade 36. Length of post and spacing of holes shall be as shown on the plans.

All delineator posts shall be hot dip galvanized and all fabrication, including punching or drilling holes, shall be completed before the posts are galvanized.

All delineators shall be fastened to the posts by means of tamper-proof fasteners as shown on the plans.

Bridge rail delineator posts shall be fastened to the bridge rail by means of galvanized U-bolts with hex nuts and lock washers.

728.03 Construction Requirements. Roadside delineator posts shall be installed along either side of the roadway 2' (0.6 m) beyond the shoulder edge or 2' (0.6 m) from the face of curbed sections. Delineators shall be located 4' (1.2 m) above the grade of the pavement edge. The post shall be driven before installing the delineator using an approved metal driving cap that fits snugly in or around the post.

Bridge rail delineators shall be mounted to the top bridge rail as shown on the plans.

White delineators shall be installed along the right side of the main lanes and ramps and shall be spaced as shown on the plans. Yellow delineators shall be installed along the left side of the main lanes and ramps and shall be spaced as shown on the plans. Red delineators shall be installed as shown on the plans.

728.04 Method of Measurement. Delineators will be measured by the unit. One unit consists of the delineator, post, brackets, and all other hardware necessary to complete the installation.

728.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Delineator of the type specified, which price shall be full compensation for furnishing, fabricating, and erecting the delineators; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Delineator (Type___)	Each

SECTION 729
CHANNEL POST SIGN SUPPORT

729.01 Description. This item shall consist of furnishing and installing channel post sign supports for roadside mounted signs according to these specifications and to the dimensions and details and at the locations shown on the plans or as directed.

729.02 Materials. The posts shall be made of a U-section channel as shown on the plans and shall be manufactured from re-rolled rail steel or equivalent. The steel shall comply with the mechanical requirements of ASTM A 499, Grade 60. The steel shall comply with the chemical requirements of ASTM A 1 for rails having a nominal weight of 90 pounds per yard (45 kg/m) or more, except as modified herein:

Carbon	0.67-0.89%
Manganese	0.70-1.00%
Silicon	0.10-0.25%

The Contractor shall submit to the Engineer certified mill test reports showing chemical analysis and physical tests.

The posts shall be a flanged channel section weighing not less than 3.00 pounds per foot (4.46 kg/m) for Type A and Type B supports and 2.00 pounds per foot (3.0 kg/m) for Type C and Type U supports. The finished posts shall be straight, have a smooth, uniform finish, and shall be free from injurious defects affecting their strength, durability, and appearance. The posts shall be fabricated such that the area of contact between the post and the sign is symmetrical about the vertical axes of both post and sign. The posts shall be punched or drilled with 3/8" (10 mm) holes on 1" (25 mm) centers for the full length of the posts. The holes shall be carefully spaced vertically and horizontally so they will align for splicing. All holes and sheared ends shall be free from burrs.

The posts for Type A, Type B, and Type C supports shall have a green enamel finish. The posts for Type U supports shall be hot dip galvanized. All fabrication, including punching or drilling holes, shall be completed before the posts are painted or galvanized.

The posts shall be a minimum of 12' (3.7 m) in length. If the height of the support requires a splice, the splice shall be made as shown on the plans.

729.03 Construction Requirements. The channel post sign support shall be constructed and installed at the locations shown on the plans or as directed. The supports shall be installed so that the signs will be plumb and to the specified vertical and horizontal clearances. The posts shall be driven before installing the signs using an approved metal driving cap that fits snugly in or around the post.

729.04 Method of Measurement. Channel Post Sign Supports will be measured by the unit. One unit consists of the post(s) and all bolts, nuts, washers, brackets, and other hardware necessary to complete the installation and mount the sign(s). The fabrication and installation of the sign will be paid for under Section 725 or 726.

729.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Channel Post Sign Support of the type specified, which price shall be full compensation for furnishing, fabricating, and installing the support; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Channel Post Sign Support (Type__)	Each

SECTION 730
BREAKAWAY SIGN SUPPORT

730.01 Description. This item shall consist of furnishing and installing breakaway sign supports for roadside mounted guide signs and standard signs according to these specifications and to the dimensions and details and at the locations shown on the plans or as directed.

730.02 Materials. The posts shall be fabricated of a galvanized steel section as shown on the plans. The length of each post for each sign shall be verified by the Contractor before ordering to meet the existing field conditions and to conform to the specified sign mounting heights. No field cutting of the post will be permitted unless approved by the Engineer.

All structural steel, except pipe posts but including base plates on pipe posts, and steel fuse plates, shall comply with AASHTO M 223 Grade 50. Pipe posts shall be structural steel complying with AASHTO M 183 or ASTM A 53 Grade B pipe. Steel bolted or welded to the primary support posts and not affecting the breakaway function, may be AASHTO M 183.

All high strength bolts, nuts, and washers shall comply with AASHTO M 164M.

Shims shall be fabricated from brass shim stock or strip complying with ASTM B 36.

Concrete for footings shall comply with Section 802 for Class S concrete. The Department will perform all acceptance sampling and

testing at the frequencies shown for Contractor acceptance testing in Subsection 802.06. Reinforcing steel shall comply with Section 804 for Grade 40.

Footings for standard sign supports shall not be reinforced.

Hardware required for attachment of the sign(s) to the support shall comply with Section 724.

730.03 Fabrication. Sign supports shall be fabricated according to the applicable provisions of Section 807. All holes in steel fuse plates and flange holes for fuse bolts shall be drilled or subpunched and reamed. All plate cuts shall preferably be saw cuts; however, flame cutting will be permitted provided all edges are ground after cutting. Metal projecting beyond the plane of the plate face will not be acceptable.

Visual inspection of all welds shall be made and any weld found defective shall be repaired only by rewelding.

All structural steel shall be galvanized after fabrication according to AASHTO M 111. All bolts, nuts, and washers shall be galvanized according to AASHTO M 232 or M 298, Class 40 or 50.

730.04 Shop Drawings. Shop drawings, in duplicate, shall be submitted to the Engineer for approval before fabrication begins. The Contractor shall be responsible for the accuracy of the drawings, even though the drawings may have been approved by the Engineer.

730.05 Construction Requirements. Excavation, backfill, compaction, and disposal of surplus materials shall be performed according to Section 801. Compaction shall be accomplished to the extent necessary to prevent future settlement of the backfill. Disturbed surfaces shall be returned to the original condition.

The applicable provisions of Sections 802 and 804 shall govern the construction and installation of concrete and reinforcing steel.

Field welding will not be permitted except upon approval in writing by the Engineer.

All sign supports shall provide a minimum vertical and horizontal clearance as shown on the plans. To ensure proper clearances, dimensions of the structure that affect clearances shall be verified by the Contractor by field measurements before fabrication begins.

Sign supports shall be erected so that the sign face is plumb and at right angles to the road unless otherwise directed by the Engineer.

Subsequent to erection, any damaged galvanized coating shall be repaired according to Subsection 807.88.

The procedure for assembly of base connection, as shown on the plans, shall be followed explicitly. The high strength bolts in the base connection shall be tightened only to the torque shown on the plans. They shall not be overtightened.

730.06 Method of Measurement. Breakaway Sign Supports will be measured by the total weight of the steel post installed and accepted, rounded to the nearest pound (kilogram). The weight will be determined by multiplying the length of each post, including both sign post and stub post, by the nominal weight per foot (meter) of the section. The weight of base plates, fuse plates, bolts, and other accessories will not be included in this measurement.

730.07 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per pound (kilogram) for Breakaway Sign Support of the type specified, which price shall be full compensation for excavation, construction of foundation, backfill, compaction, removal and disposal of surplus materials, and replacement of existing surfaces; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Breakaway Sign Support (Type___)	Pound (Kilogram)

SECTION 731
IMPACT ATTENUATION BARRIER

731.01 Description. This item shall consist of furnishing, installing, relocating, maintaining, repairing, and removing temporary and permanent impact attenuation barrier systems, including pads, nose covers, and transitions. The impact attenuation barrier system shall be of the type shown on the plans. The impact attenuation barrier system shall satisfy the National Cooperative

Highway Research Program (NCHRP) Report 350 or the Manual for Assessing Safety Hardware (MASH) requirements for a Test Level 3 (TL-3) crash cushion. A copy of the Federal Highway Administration's (FHWA) acceptance letter with all attachments for each impact attenuation barrier system shall be submitted to the Engineer. Impact attenuation barrier systems shall be fabricated and installed in accordance with the plans and with the crash testing documentation provided in the FHWA acceptance letter, which is available at FHWA's website at: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/, if current testing criteria have been fulfilled.

731.02 Materials. The Contractor shall furnish a certification from the manufacturer or supplier that the impact attenuation barrier supplied is non-gating, redirective and meets the requirements of NCHRP Report 350 or MASH for a TL-3 crash cushion.

An impact attenuation barrier system specifically designed for protecting motorists from impacting temporary concrete barrier walls or other fixed objects adjacent to the roadway shall be utilized. The impact attenuation barrier system shall be non-gating, redirective and compatible with the site geometry shown on the plans. Sand Barrels will not be allowed for Temporary Impact Attenuation Barriers.

Sand barrier installations shall consist of a foundation pad and modules consisting of three basic components: cylinder, lid, and spacer. The Contractor shall have the option of constructing either a rigid or flexible foundation pad.

The material requirements for the barrier installation are as follows:

(a) Rigid Pad. A rigid pad shall be constructed of a course of concrete of the thickness shown on the plans. Concrete shall comply with Section 802 for Class M concrete. The Department will perform all acceptance sampling and testing at the frequencies shown for Contractor acceptance testing in Subsection 802.06.

(b) Flexible Pad. A flexible pad shall be constructed of Aggregate Base Course, Class 1, and ACHM Surface Course, to the dimensions shown on the plans. At the option of the Contractor, full depth ACHM Surface Course may be used to construct the flexible

pad. Materials shall comply with the requirements for the appropriate items of Sections 303 and 407.

(c) Cylinder. The cylinders shall be 36" (900 mm) in diameter and may be either 30" or 36" (750 mm or 900 mm) in height. The cylinders shall be molded from a tough, high density, polyethylene material that is durable and weatherproof, having a thickness of approximately 1/4" (6 mm). The cylinder shall be of such design, material, and construction as to shatter upon impact. Unless otherwise specified, the color of the cylinder shall be yellow.

(d) Lid. The lid shall be formed from high density polyethylene and shall be of such diameter as to ensure a tight fit.

(e) Spacer. The spacer shall be in the form of a core with a disc and seal supporting the sand mass or an inner container with a stem. The spacer heights shall be designed to ensure that the center of gravity of each module is at the proper elevation to control the attitude of impacting vehicles.

(f) Sand. Sand may be any type of building sand of average grain texture. Wet sand from outside storage or on open trucks, exposed to rain, is acceptable, provided it is not saturated to a liquid or semi-liquid state.

731.03 Construction Requirements. The subgrade area for the foundation pad shall be shaped and compacted to the required section. Compaction shall be accomplished by any method satisfactory to the Engineer. The foundation pad shall be constructed as stated above. Each module shall be placed at the location and to the dimensions shown on the plans. The Contractor shall be responsible for outlining with paint the location of the modules for future reference. The Contractor shall mark (with paint) the weight of sand in each module as indicated on the specific site plan. The modules shall be placed in front of the hazardous object according to the dimensions shown on the plans. To facilitate lid installation there shall be a 3/8" - 5/8" (10 mm - 15 mm) clearance between module tops.

After the cylinder is placed in proper location and the proper spacer is assembled and placed in the cylinder, sand shall be placed to the required depth as coded on the module and the lid securely installed.

Impact attenuation barrier system shall be fabricated and installed according to the manufacturer's most current recommendations and installation methods. Any damage caused by the Contractor to the materials required for the impact attenuation barrier system shall be repaired or replaced immediately at no cost to the Department.

In the event that the impact attenuation barrier system is damaged at no fault of the Contractor, all damaged parts shall be replaced immediately by the Contractor to restore the Impact Attenuation Barrier to a fully functional condition. Replacing damaged parts will be paid for under the item Temporary Impact Attenuation Barrier (Repair). In the event that a crash cushion is damaged beyond repair at no fault of the Contractor, it shall be immediately replaced and paid for under the item Temporary Impact Attenuation Barrier.

731.04 Method of Measurement. Impact Attenuation Barrier Systems will be measured by the unit of the type specified. Each unit shall include a foundation pad and a specified number of impact modules, when applicable. Temporary Impact Attenuation Barrier previously furnished and installed, which is authorized to be relocated, will be measured by the unit. Relocations for the convenience of the Contractor will be at no additional cost to the Department.

731.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Temporary or permanent Impact Attenuation Barrier of the type specified, which price shall be full compensation for excavation and/or embankment; for construction of the pad; for furnishing and installing cylinders, complete with filler and lids; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Impact Attenuation Barrier (Type___)	Each
Temporary Impact Attenuation Barrier	Each
Temporary Impact Attenuation Barrier (Relocation)	Each
Temporary Impact Attenuation Barrier (Repair)	Each
Temporary Impact Attenuation Barrier Left in Place	Each

SECTION 732
CRASH CUSHIONS

732.01 Description. This item shall consist of constructing a foundation pad including excavation and/or embankment, transitions from bridge ends, and a backup wall, when specified, and furnishing and installing a crash cushion according to these specifications and to the dimensions and at the locations shown on the plans or as directed. The crash cushion shall satisfy the National Cooperative Highway Research Program (NCHRP) Report 350 or the Manual for Assessing Safety Hardware (MASH) requirements for a test level 3 (TL-3) crash cushion.

732.02 Materials. (a) Foundation Pad and Backup Wall.

(1) Concrete shall comply with Section 802 for Class M concrete. The Department will perform all acceptance sampling and testing at the frequencies shown for Contractor acceptance testing in Subsection 802.06.

(2) Reinforcing steel shall comply with Section 804.

(3) Preformed joint filler shall comply with AASHTO M 153, Type I.

(b) Crash Cushion. The Contractor shall furnish a certification from the manufacturer or supplier that the crash cushion meets the requirements of NCHRP Report 350 or MASH for a TL-3 crash cushion. The crash cushion shall comply with the most current specifications and details for a guardrail energy absorbing terminal crash cushion as recommended by the manufacturer and as approved by the Engineer.

The Contractor shall provide the Engineer with copies of all necessary manufacturer's details and installation manuals prior to the installation of the crash cushion on the project. These materials shall remain the property of the Department.

732.03 Construction Requirements. The subgrade area for the foundation pad shall be shaped and compacted to the required section. Compaction shall be accomplished by any method satisfactory to the Engineer.

The foundation pad, including curb transition from bridge ends, and backup wall shall be constructed to the lines and dimensions shown on the plans. The backup wall shall also be constructed according to Section 631.

The crash cushion shall be installed according to the manufacturer's current recommendations and installation methods.

732.04 Method of Measurement. Crash Cushions will be measured by the unit. Each unit shall include one crash cushion and foundation pad with curb transitions, when specified.

Backup Wall will be measured by the linear foot (meter).

732.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Crash Cushion or per linear foot (meter) for Backup Wall, when specified, which price shall be full compensation for excavation and/or embankment; for construction of the foundation pad, with curb transitions when specified; for furnishing and installing the crash cushion; for construction of the backup wall, when specified; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
Crash Cushion	Each
Backup Wall	Linear Foot (Meter)

SECTION 733
VIDEO DETECTOR WITH RADIO INTERFACE

733.01 Description. This item shall consist of furnishing and installing a Video Detector, Video Processor, Cable, Video Monitor, Radio Interface and other hardware and software in accordance with these specifications, and modification of remote video monitoring site(s), at the locations shown on the plans or as directed by the Engineer, for the purpose of providing actuation to a traffic signal controller and for live video monitoring of traffic conditions at the site.

Video detection consists of a Video Detector, Video Processor, Video Cable and other associated equipment and shall measure vehicle information by the means described, process the information and provide vehicle actuation to an actuated controller, system local controller, or other device as outlined in the plans or Contract. In addition, where radio cameras are specified, video signal shall be transmitted back to a central site by means of radio interface. Live video shall be available through standard phone modem connection to a remote location. Video Detection equipment and its associated components shall also meet the environmental and electrical requirements in Section 701.

733.02 Materials. (a) Video Detector. All video detectors shall consist of a black and white (BW) video camera with zoom lens, cable, manual pan and tilt bracket, wiring harness and all other accessories. Camera and lens shall have sufficient resolution to discriminate between vehicles in one lane at 300 feet (91 meters) with the detector mounted at a height of 30 feet (9.1 m) above the roadway surface. Output shall be Composite video 75 Ohm Ivtt CCIR/EIA. Where called for on the plans, the Detector mounting shall include hardware for mounting on the traffic signal mast arm. The mounting bracket shall position the Detector approximately five feet (5′) [1.5 m] above the arm as shown on the plans.

(b) Video Detector-Radio Interface (RX). Where radio interface (RX) is specified, the Video Detector shall include an FCC approved radio transmitter unit (RX). RX may be internal to camera, or mounted separately in a cabinet. Where mounted separately, furnishing and installation of the cabinet shall be considered included in the unit price bid for the Video Detector-RX. Receiver/Transmitter system shall have a minimum range of 1500 feet (457 m), line of sight. Furnishing and installation of the antenna, antenna cable, wire, and all wiring shall be considered included in the unit price bid for Video Detector-RX.

(c) Video Radio Receiver. Unit shall be shelf mounted. Power supply may be separate or internal, but shall not require power from the traffic signal controller unit (timer). The unit shall receive radio signals from the number channels specified, and relay video signal to the Video Processor unit. The furnishing and installation of the antenna, antenna cable, wire, and all wiring shall be considered included in the unit price bid for Video Radio Receiver.

(d) Video Processor Unit. The unit shall be located in a cabinet provided under the item "Actuated Controller". Processor shall provide for a minimum of 24 detector zones, which are user selectable and programmable. Furnishing and installation of the wiring and wiring harness from the Video Processor Unit to the traffic signal controller shall be considered subsidiary to the unit price bid for Video Processor Unit. The Video Processor Unit shall comply with the following:

Video Input:	Composite video 75 Ohm Ivtt CCIR/EIA
Output:	Analog video output with system information, data and detection zones
	8 isolated vehicle detection channels
	Auto diagnostic LED indicators for state of tuning, fault or error condition

One programming module per job shall be provided for alignment and setup of Detector. This shall be considered subsidiary to the Video Processor Unit.

(e) Video Cable. Video cable shall be the type and size recommended by the manufacturer of the Video Processor Unit and shall consist of all cable necessary for supplying power to the Detector, transferring programming information to and from a remote data terminal, and for transfer of video data between the Video Detector and the Video Processor Unit. No splices are allowed in Video Cable without specific approval of the engineer.

(f) Video Monitor. Where called for in the plans, a video monitor meeting the following shall be provided:

- Display - Black & White (B/W) or Color (Clr) as specified
- Size –9″ (225 mm) Diagonal
- Input/Output looping with 75/High Ohm Switchable, BNC Termination
- Power Indicator light and switch
- Input Power – 120 VAC

(g) Remote Video Monitoring. Live video monitoring shall be available via. telephone dial up utilizing a modem as specified in the plans.

733.03 Construction Requirements. The Video Detector is typically installed on a pole, arm or other structure as described on the plan sheets.

(a) Installation. The Contractor shall furnish and properly install each unit with accessory equipment and perform the necessary connections, testing of circuits, adjustments, and such other operations as may be necessary to ensure that each complete installation, with all of its components, be completely integrated and tested as a unit so that the desired control of the system is attained, complete, and in the best of working order, to the satisfaction of the Engineer.

(b) Setup and Programming. The Contractor shall provide all necessary equipment for testing, configuring detection zones, on-site monitoring, and other programming of video processor unit and Detector(s) utilized in the system. Any equipment required for programming but not listed in the summary of quantities will remain the property of the contractor but shall be available for further testing and reconfiguring of the zones until the project is accepted as final.

(c) Software. Software required for monitoring, setup and programming of the system shall be supplied as subsidiary to the item "Video Processor" of the number of channels specified. Two licensed copies shall be provided for each project. Software shall be Windows based and operate on a system using an IBM compatible laptop with Intel Pentium III processor and Windows 2000 or later operating system. If any other programming device is required for the equipment supplied, the Contractor shall supply one device which shall become the property of the Department or agency responsible for operation of the signal. No additional payment will be made for furnishing the programming device(s).

(d) Remote Video Site Modification. The Contractor shall remove all unnecessary equipment; modify the existing cabinet, wiring, and conduit as needed; and provide and install any incidental devices, suppressors, brackets and wiring; and program and test the device.

(e) Documentation, System Timing and Operation Test. The Contractor shall provide a minimum of 14 days notice prior to placing the system into operation. A manufacturer's representative

shall be present at the time of turn on and shall provide assistance and operational instructions to Department personnel in setup and programming of the system.

733.04 Method of Measurement. Work completed and accepted under this item will be measured as follows:

(a) Video Detector shall be measured by the unit.

(b) Video Detector-RX shall be measured by the unit.

(c) Video Detector Relocation shall be measured by the unit.

(d) Video Radio Receiver of the number channels specified, shall be measured by the unit.

(e) Video Processor, of the number channels specified, shall be measured by the unit.

(f) Video Cable shall be measured by the linear foot (meter).

(g) Video Monitor of the type specified will be measured by the unit.

(h) Remote Video Site Modification shall be measured by the unit.

733.05 Basis of Payment. (a) Video Detector. Work completed and accepted under this item and measured as provided above, shall be paid for at the contract unit price bid per each for Video Detector; which price shall be full compensation for providing and installing the device, wiring and testing, aligning the zones; and shall also be for all labor, equipment, tools and incidentals necessary to complete the work.

(b) Video Detector-RX. Work completed and accepted under this item and measured as provided above, shall be paid for at the contract unit price bid per each for Video Detector-RX; which price shall be full compensation for providing and installing the device, brackets and extension, wiring; for programming and testing the device; for furnishing and installing cabinet for separate radio transmitter unit installations; for furnishing and installing the antenna, antenna cable, wire, and all necessary wiring; and for all labor, equipment, tools and incidentals necessary to complete the work.

(c) Video Detector Relocation. Work completed and accepted under this item and measured as provided above, shall be paid for at the contract unit price bid per each for Video Detector Relocation; which price shall be full compensation for removing the device from present site, installing the device at the new location, and for furnishing and installing brackets and extensions, wiring and testing; and for all labor, equipment, tools and incidentals necessary to complete the work.

(d) Video Radio Receiver. Work completed and accepted under this item and measured as provided above, shall be paid for at the contract unit price bid per each for Video Radio Receiver of the number channels specified; which price shall be full compensation for providing and installing the device, brackets and extensions, wiring and testing the device; and for furnishing and installing the antenna, antenna cable, wire, and all necessary wiring.

(e) Video Processor. Work completed and accepted under this item and measured as provided above, shall be paid for at the contract unit price bid per each for Video Processor of the number channels specified; which price shall be full compensation for providing and installing the device, wiring, configuring, and testing the device; furnishing and installing wiring and wiring harness from the video processor unit to the traffic signal controller; and for all labor, equipment, tools and incidentals necessary to complete the work.

(f) Video Cable. Work completed and accepted under this item and measured as provided above shall be paid for at the contract price bid per linear foot (meter) for Video Cable; which price shall be full compensation for providing and installing all cable, including video, power supply and data cables from the Video Processor to the Video Detector, which cable shall not be measured separately but as one unit per Detector; and shall include all labor, equipment, tools and incidentals necessary to complete the work.

(g) Video Monitor. Work completed and accepted under this item and measured as provided above, shall be paid for at the contract unit price bid per each for Video Monitor of the type specified; which price shall be full compensation for providing and installing the device, wiring, configuring, and testing the device; and for all labor, equipment, tools and incidentals necessary to complete the work.

(h) Remote Video Site Modification. Work completed and accepted under this item and measured as provided above, shall be paid for at the contract unit price for Remote Video Site Modification; which price shall be full compensation for removing

all unnecessary equipment; modifying existing cabinet, wiring and conduit as needed; and for providing and installing any incidental devices, suppressors, brackets and wiring; and for programming and testing the device.

Payment will be made under:

Pay Item	**Pay Unit**
Video Detector	Each
Video Detector –RX	Each
Video Detector Relocation	Each
Video Radio Receiver (__ Channel)	Each
Video Processor (__ Channel)	Each
Video Cable	Linear Foot (Meter)
Video Monitor (CLR)	Each
Video Monitor (B/W)	Each
Remote Video Site Modification	Each

SECTION 734
BRIDGE END TERMINAL

734.01 Description. This item shall consist of furnishing and installing an acceptable crashworthy terminal at bridge ends at the locations shown in the plans or as directed by the Engineer. The bridge end terminal shall satisfy the National Cooperative Highway Research Program (NCHRP) Report 350 or the Manual for Assessing Safety Hardware (MASH) requirements for a test level 3 (TL-3) terminal.

The bridge end terminal shall be of a configuration that will be compatible with the subgrade width and site geometry shown on the plans. Bridge end terminals that require grading beyond the limits shown on the plans will not be acceptable.

734.02 Materials. (a) Foundation Pad and Backup Wall. Concrete shall conform to the requirements of Section 802 for Class A or Class S Concrete or Section 501 for paving concrete. The

Department will perform all acceptance sampling and testing at the frequencies shown for Contractor acceptance testing in Subsection 802.06. Reinforcing steel shall conform to the requirements of Section 804.

(b) Bridge End Terminal. The Contractor shall furnish a certification from the manufacturer or supplier that the bridge end terminal is non-gating, redirective and meets the requirements of NCHRP Report 350 or MASH for a TL-3 terminal. All materials shall be new and shall conform to the most current specifications and details recommended by the manufacturer and as approved by the Engineer. All parts shall be clearly identified for proper assembly and replacement.

The Contractor shall provide the Engineer with copies of all necessary manufacturer's details and installation manuals prior to the installation of the bridge end terminal on the project. These materials shall remain the property of the Department.

734.03 Construction Requirements. The subgrade for the foundation pad shall be shaped and compacted to the required section as directed by the Engineer.

The foundation pad, including curb transition from bridge ends, and backup wall, if required, shall be constructed according to the details provided by the manufacturer.

The bridge end terminal shall be fabricated and installed according to the manufacturer's most current recommendations and installation methods. Any damage caused by the Contractor to the materials required for the bridge end terminal shall be repaired or replaced immediately at no cost to the Department.

734.04 Method of Measurement. Bridge End Terminal completed and accepted under this item will be measured by the unit. Each unit shall include one bridge end terminal, foundation pad with curb transitions and backup wall, if required.

734.05 Basis of Payment. Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per each for Bridge End Terminal, which price shall be full compensation for shaping and compacting the subgrade; for constructing the foundation pad, with curb transitions; for constructing the backup wall, if required; for furnishing and

installing the bridge end terminal; and for all materials, labor, equipment, tools and incidentals necessary to complete the work.

Pay Item	**Pay Unit**
Bridge End Terminal	Each