

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
Road Edge Delineator (Standard and Type)	Each
Barrier Delineator	Each
Guardrail Delineator	Each

## SECTION 703—TRAFFIC SIGNALS

### 703.01—Description.

This work shall consist of furnishing and installing traffic signal equipment in accordance with these specifications and as shown on the plans or as directed by the Engineer. The terminology used herein and on the plans shall be as generically interpreted by manufacturers in the field except that certain terminology shall be interpreted as follows:

- (a) **auxiliary equipment:** separate devices used to add supplementary features to a controller, such as conflict monitors, load switches, and flashers
- (b) **manufacturer:** the company that assumes the responsibility for producing and assembling the equipment and that is responsible for guaranties and warranties for the equipment
- (c) **system:** the coordination of traffic signals through a time relationship or by interconnection of controllers with a master controller or computer to permit coordinated movement along a street(s)
- (d) **system manufacturer:** the company or system supplier that assumes the responsibility for procuring and assembling the equipment and that is responsible for guaranties and warranties for the equipment

### 703.02—Equipment.

Traffic signal controllers, master controllers, auxiliary equipment, and flashers for operating flashing beacons furnished by the Contractor shall be certified by the manufacturer as conforming to the requirements of NEMA TS-1 and any exceptions and additions stated herein unless otherwise specified. The manufacturer shall also provide certification from an independent testing laboratory that the model of controller, auxiliary equipment, and flasher furnished conforms to NEMA environmental standards and test procedures. Controllers and auxiliary equipment shall be the manufacturer's standard design. Controllers shall be furnished completely housed in a waterproof cabinet. Controllers and auxiliary equipment shall operate from a 120-volt, 60-Hz, single-phase, AC power supply. The manufacturer's name, model number, serial number, and part identification number shall be permanently

attached to the cover of the equipment. The Contractor shall furnish the manufacturer's instructions for installing and maintaining the equipment.

The Contractor shall provide at least 15 hours of training for Department personnel in the operation, timing, maintenance, and repair of the signal equipment supplied by the Contractor. Training shall consist of at least 50 percent hands-on training. Training shall be held at a location specified by the Department and conducted by a qualified instructor representing the equipment manufacturer. Training material shall contain "hand-outs" for each attendee which shall serve not only as subject guidance, but as quick reference material for future use by the students. The Contractor shall also provide training on VHS tapes.

The Contractor shall secure assistance from the manufacturer as necessary to produce, implement, and fine-tune the controller, coordination, and preemption timings required to provide for an orderly movement of traffic as approved by the Engineer. Coordination timings shall include plans for morning and afternoon peak hours and off-peak conditions. The Department will furnish traffic counts for the Contractor's use in producing the timings within 30 days of the Contractor's request to the Engineer. The Contractor shall furnish to the Department three copies of the timing data and documentations used in calculating the timings. These data shall be submitted for approval 60 days prior to timing implementation. When specified on the plans, the Department will supply the final timing plan for implementation and fine-tuning by the Contractor. The Contractor shall request the final timing plan at least 90 days in advance of implementation.

- (a) **Traffic Signal Controllers:** Controllers shall be eight phase, traffic actuated, solid state, and digital. Controllers shall be capable of operation in a closed loop traffic control system by the addition of a communication module/board and closed loop system software. No additional changes to the controllers shall be required. Controllers shall be completely modular consisting of a main frame and plug-in modules/boards that can be secured in place but easily removed for inspection and servicing.

**Controllers** shall also include the following programmable features:

- Volume density functions.
- Pedestrian functions.
- Four signal overlaps with extension timing capability to allow the overlap green to extend beyond the parent green by a user programmable time. Amber and all red clearances shall be programmable for the overlaps when extension timing is utilized.

**Phasing:**

- Concurrent phasing.
- Sequential phasing in ascending numerical order.

- Concurrent phasing on one side of the barrier (compatibility line) and sequential phasing on the other side.
- Reversal of phases in the same ring on the same side of the barrier.

**Soft Recall:**

- Places a demand on a phase(s) when no other calls exist.

**Conditional Service:**

- Allows an odd phase to be reserviced after the even phase but prior to crossing the barrier provided the following conditions are met:
- Even phase in the same ring has gapped out and is resting.
- A call exists across the barrier.
- Even phase in the opposite ring is still extending with enough time left in its max timer. Time shall be equal to or greater than the minimum green of the phase about to be served plus the even-phase-same-ring's clearance times.

**Last Car Passage:**

- Allows for timing a full passage time when a phase gaps-out.

**Security Code:**

- When enabled, a user specified security code is required to be entered before data may be changed. Security access shall be automatically rescinded 10 minutes after last user keystroke or 10 minutes after access if there are no user keystrokes. Viewing of data shall not require the entering of the security code. In closed loop systems, central equipment shall have free access to data within the local controllers via the master controller regardless of security codes imposed at the local controllers.
- Controllers shall have an auxiliary connector mounted on the front panel that will allow the following functions to be accomplished in accordance with the Electronic Industries Association's RS-232C interface standard. Accomplishment of these functions shall be capable while the controllers are in normal operation without any adverse effects.

**Data Transfer:**

- All user-entered data shall be transferable to other controllers of the same manufacturer and model through the use of a data transfer

cable connected to the auxiliary connector on the controllers. Messages shall be displayed on the LCD when transfer is completed and when there is an error in transmission. The Contractor shall furnish 2 data transfer cables to the Department unless otherwise indicated on the plans.

**Downloading and Uploading of Data:**

- Controller manufacturer developed menu driven computer software shall provide for the downloading and uploading of user entered data between the controllers and an IBM or IBM compatible computer with a 20MB minimum hard drive, and operation of the following functions.
  - Creation, review and modification of user entered data
  - Creation, review and modification of intersection configurations including but not limited to graphic display of intersection geometrics, laneage, street names, phases and overlaps. Standard intersection geometric graphics consisting of at least a four leg approach, tee, offset tees and diamond interchanges that are user selectable for use in creating intersection configurations shall be included in the software.
  - Transfer of user entered data except real time and date from one intersection's database to another intersection's database.
  - Comparison of an intersection's database and reports stored on disk to that uploaded from the intersection's controller. Differences shall be indicated.
  - Storage and retrieval of an intersection's database and configurations to and from diskettes.
  - Printout of an intersection's database through a printer.
  - Display of controller status while connected to the controller.
- The number of intersections whose database and configurations can be stored, retrieved and downloaded from and to a diskette shall only be limited by available space on the diskette. Each intersection file shall be uniquely identified and accessible by an alphanumeric name. Cross-referencing of the alphanumeric name to the intersection name shall be provided if different.
- Connection of the controller to the computer shall be accomplished through the use of a cable with a DB-9 female connector on one end for connection to the computer and the appropriate connector on the other end for connection to the controller auxiliary connector.

- The Contractor shall furnish manufacturer's certification that software on 3.5-inch (1.44 MB) diskettes and connecting cables are available which will provide for operation of the above functions.

**Printing:**

- All user entered data and reports shall be capable of being downloaded to a serial printer in a usable format. Data to be printed shall be selectable by the user from at least the following submenus:
  - Controller
  - Coordination
  - Time base coordination
  - Preemption
- Terminologies other than those listed above may be used provided they are readily identifiable to the user. Connection of the controller to the printer shall be accomplished through the use of a cable with a DB-25 male connector on one end for connection to the printer and the appropriate connector on the other end for connection to the controller auxiliary connector. The Contractor shall furnish 2 cables to the Department unless otherwise indicated on the plans. Messages shall be displayed on the LCD indicating when printing is completed and when there is an error in transmission.
- Controllers shall have internal traffic adjusted system coordination (hardwire), non-interconnected system coordination (time base) and preemption. Coordination commands shall be accepted and responded to by the controllers regardless of the phasing utilized. Controllers shall have coordination outputs to allow its use as a master controller transmitting coordination commands based upon time of day.

**Coordination:**

- Coordination shall provide for at least 4-cycle lengths, 3 offsets per cycle plan, 3 splits per cycle plan, 3 permissive periods per split plan, 8 force-offs per split plan and remote flash operation. Shortway smoothing routine shall be provided to smooth coordination plan cycle and offset changes.
- Traffic adjusted system coordination shall be designed to operate with an impulse through an interconnect cable from a master controller.
- Non-interconnected system coordination shall be designed for coordination of signals based upon time of day and without the use of interconnect cable.

In addition to the requirements stated under coordination, minimum program functions shall conform to one of the following two types:

Type 1	Type 2
150 event times	180 event times
150 time of day functions	48 time of day functions
10 day programs	7 day week program
8 week programs	99 exceptions to the week program
1 year program	synch reference by time and event
10 unique exceptions to the year program	3 auxiliary outputs
synch reference by time and event	Max II selection
3 auxiliary outputs	Phase reversal
Max II selection	
Phase reversal	

**Definitions:**

- An event time is an hour, minute, and second of a 24-hour day. A time of day function can occur at any of these times.
- A time of day function is a selection of a coordination plan condition or the time switching of an output.
- A day program is a list of the time of day functions for the day. These events specify which coordination plan conditions are selected and which outputs switch during the day.
- A week program specifies which day program shall be used on each day of the week.
- A year program specifies which week program shall be used during each week of the year.
- An exception to the year program causes a day program different from that in the year program to be used on a specific day.

Internal preemption shall provide at least one (1) railroad preemption plan and four (4) emergency vehicle preemption plans that will interrupt the normal operation of the controller upon actuation and initiate a special sequence of operation as shown on the plans. Preemption operation shall be programmable to proceed sequentially through the preemption intervals and hold at the end of a specified interval. Intervals in the preemption plan during which normal cyclic operations resume shall be pro-

grammable. Priority of preemption plans shall be programmable or shall be fixed based upon the plan number.

Activation of railroad preemption during the timing of an emergency vehicle preemption will cause the emergency vehicle preemption to immediately clear through normal clearance intervals and initiation of the railroad preemption. Railroad preemption shall be displayed for the duration of the preemption call.

Emergency vehicle preemption timings shall be programmable from at least 0 to 99 seconds. The capability of a delay between the time the emergency vehicle preemption plan input is asserted and the implementation of the preemption plan shall be provided. The timing range for this delay shall be at least 0 to 99 seconds. Emergency vehicle preemption inputs shall be capable of operating in lock and non-lock modes. When programmed non-lock, termination of the input prior to implementation of the preemption plan shall not initiate preemption operation.

Controllers shall be programmed for all required functions through a menu driven keyboard and a LCD except the following which may be programmed with dip switches or a combination of keyboard and dip switches.

- Phasing other than NEMA standard dual ring concurrent.
- Phase reversals.
- Security code on and off.
- Startup signal display indication.

The LCD shall be capable of displaying at least 4 lines of 20 characters each. The LCD shall have backlighting and automatically adjusted or selectable contrast levels for optimum viewing.

Backlighting shall be automatically extinguished within one hour after the last keyboard operation. A main menu and submenus shall be provided on the LCD which lists categories in the English language from which the user may select. Entering of data outside of allowable timing ranges shall result in the controller rejecting the data. Controllers shall have circuitry for monitoring the cycling of the microprocessor. Upon determination the microprocessor is not cycling, this circuitry shall automatically cause the intersection to be placed in flashing operation. Active status indications of controller, coordination and preemption features and timings shall be displayed on the LCD using alphanumeric characters. In addition to the indications required by NEMA, the following indications shall also be displayed:

- **Controller Status:**
  - Time and date
  - Overlaps in service

- Interval timings
  - Stop time applied
  - Phase omit active
  - Ped omit active
  - Recall type
  - Variable initial timing
  - Time before reduction timing
  - Gap time
  - Last car passage active
- **Coordination Status:**
    - Command source, e.g. manual, telemetry, time base coordination, interconnect, free or flash
    - Cycle, split and offset number active
    - Cycle length
    - Offset time
    - Local cycle timing
    - Master cycle timing
    - Offset seeking indication
    - Telemetry and interconnect failure indications
    - Vehicle permissive period active
    - Ped permissive period active
    - Hold active
    - Auxiliary output circuit number active
  - **Preemption Status**
    - Preemption number active
    - Preemption interval
    - Preemption timing

Controllers shall have an internal 99-year real-time clock referenced to the 60 Hz AC power line. Clock shall be easily set to the nearest second of the year. A crystal oscillator shall be provided to maintain clock accuracy to at least 0.005 percent (50 PPM) when on stand-by power. Clock time and date shall be maintained for at least 60 days during periods of power loss. If clock standby power is exhausted during a line voltage power failure, time base coordination shall be prevented from operation. Automatic corrections shall be made for Daylight Saving Time.

All controller user entered data except time and date shall be maintained during power outages through the use of an Electrically Erasable Programmable Read Only Memory (EEPROM).

Unless otherwise specified, the controllers shall be furnished to initially operate as follows:

- Single Entry
- Start in Major Street through phase green interval

- (b) **Flashers for Operating Flashing Beacons:** Flashers shall be solid-state, double circuit, and shall be furnished complete in a weatherproof cabinet. The cabinet shall be fabricated of welded sheet aluminum at least 0.125 inch in thickness.

The cabinet shall have transient protection conforming to the requirements of (d)3.b. herein for field wiring, a door gasket, and a standard police panel lock with two keys. A radio frequency interference filter rated at 20 amps, terminal block, and 20-amp circuit breaker shall be mounted in the cabinet. The cabinet shall be provided with removable hub plates tapped for 1-inch conduit at the top and bottom and shall be equipped with brackets for wood-pole mounting or with adjustable bands for steel-pole mounting as specified on the plans.

- (c) **Master Controller:** Master controllers shall be solid-state, digital, traffic-adjusted controllers adaptable to fully actuated local controllers. They shall provide for at least 3 cycle lengths, three independent offsets per cycle, and free operation and shall be capable of volume density computations. Master controllers shall be from the same manufacturer as the local controllers furnished by the Contractor.
- (d) **Cabinets:** Cabinets for traffic signal controllers and master controllers shall be weatherproof and constructed of welded sheet aluminum, 0.125-inch minimum. Cabinet mounting attachments shall be durable, corrosion resistant, and of heavy-duty construction.

Cabinets shall be at least 54 inches in height, 44 inches in width, and 24 inches in depth and shall be large enough to provide for ease of maintenance of the controller and auxiliary equipment. The maximum width and depth shall be such that the cabinet will fit entirely on the standard CF-1 foundation. The cabinet bolt pattern shall be rectangular, with dimensions of 40 5/8 inches in width and 18 1/2 inches in depth. Anchor bolts shall be 3/4 inch in diameter and at least 16 inches in length with a 5-inch L bend.

1. **Doors:** Cabinet doors shall provide full access to the cabinet interior and shall have gaskets to ensure weatherproofing. A small recessed police panel with a separate access door shall be provided in the front door of the cabinet. The main door shall be equipped with the Department's standard tumbler lock No. 9R48773 or the municipality's standard tumbler lock and shall be keyed. The police panel shall be provided with a standard police panel lock. Two keys for each lock shall be provided the Engineer. Hinges shall be stainless steel and continuous. The main door shall have a door stop arrangement that will allow it to be firmly positioned at both 90 and 135 degrees,  $\pm 10$  degrees. The locking mechanism for cabinets shall be a three-point draw roller system. Rollers shall be fabricated from nylon with a diameter of at least 8/10 inch. The door opening shall be double flanged on all four sides.

A panel shall be mounted on the inside of the main door of the master controller cabinet and shall consist of the following four functional switches: auto-manual, manual cycle selector (three cycles), manual offset selector (three offsets), and manual synch.

2. **Police panel:** The police panel shall be furnished with two toggle switches, each labeled for its purpose. One switch will be used to place the signal in flashing operation and shall not affect the power being supplied to the controller and conflict monitor. The cyclic operation of the controller shall not be affected by this switch. Upon placement of the switch from the automatic position to the flash position, the intersection shall immediately be placed in flashing operation. Upon placement of the switch from the flash position to the automatic position, the signals shall immediately be placed in automatic operation in the major street through phase green interval. The second switch shall be used to disconnect power to the controller. The backside of the police panel shall have an aluminum cover over the switches and their wiring connections. When required by the plans, a third toggle switch with a handle control shall be furnished that will allow manual operation of controller phasing.
3. **Interior:** The interior of cabinets shall be of sufficient size to provide adequate ventilation of the equipment housed therein. Cabinets shall contain at least three adjustable shelves or equivalent supports with enough space to hold the controller, 20 single-channel detector amplifiers, and required auxiliary equipment. Vertical mounting channels for the shelves shall be continuous and shall allow for adjustable shelf placement ranging 5 inches from the bottom to 5 inches from the top of the cabinet. Wiring panels (terminal blocks) shall be neatly finished and clearly and permanently marked with identifications applied by silk screening. Conductors shall be neatly arranged in the cabinets and bundled in groups with cable ties. Conductors running to panels other than the resistor panel on the left side of the cabinet shall be positioned below the resistor panel with the nearest conductor being at least three inches from the bottom resistor position. Conductors connected to terminals located on the door shall be bundled and sheathed. The bundled conductors shall not obstruct access to other circuits and terminals in the cabinet. The controller equipment and terminals shall be arranged within the cabinet so that they will not interfere with the entrance, tracing, and connection of conductors. Unless cable is passing through the cabinet uninterrupted, incoming and outgoing conductors shall have each wire connected to terminal post positions.

Cabinets shall be wired in accordance with Section 10 of NEMA TS-1 for NEMA configuration 8 and the changes and additions noted herein. The cabinet shall also be wired to produce controller pin connector functions, including those on auxiliary connectors.

Wiring that is connected to the back panel shall be of adequate length to allow the back panel to be placed in position for maintenance.

When exclusive/permissive left-turn phasing is being used, the red output from the load switch for the left-turn phase shall be connected to ground through a 1.5K-ohm resistor. The resistor shall conform to the requirements of MIL-R18546D, Type RE70G1501. Heat sink compound shall be applied to the housing base prior to attachment. Wiring shall be soldered to the resistors and the connections shall then be covered with heat shrink tubing. On unused phases, red outputs shall be wired to AC+. Wiring shall be readily accessible and shall not require the back panel to be lowered for disconnection of the wiring.

Cabinet wiring shall be provided for railroad preemption whereby the selection of the following is easily accomplished through the use of simple hand tools: (1) 115 VAC or ground true outputs, and (2) normally open or normally closed contacts.

The Contractor shall provide five blue and white prints of the controller circuit diagram. The blue and white prints shall be produced from the original drawing and shall be clear and legible. The Contractor shall install two copies of the circuit diagram inside the cabinet in a readily accessible waterproof enclosure and shall furnish three additional copies to the Engineer. The waterproof enclosure shall be securely attached to the cabinet with studs welded to the cabinet and nuts. The enclosure shall have noncorrosive metal grommets for use with the studs.

A listing indicating terminal numbers with a description of their use shall be attached to the cabinet door and overlaid with a clear, plastic covering. Edges of the plastic shall be sealed with a clear waterproofing compound.

Detector harness cables shall be stranded copper and shall be not sized less than No. 22 AWG rated at 300 volts. Other AC and DC circuit wiring shall be in accordance with NEMA TS-1. Ribbon cable and printed circuit boards will not be allowed for cabinet wiring. Loop detector harnesses shall include wires connected to the two reserved pins in the connector. At the end of the harnesses, these wires shall be folded back and tied to the harnesses with nylon cable ties. Loop input wiring in the loop detector harnesses shall have soldered on spade connectors for attachment to the detector panel terminals. Heat shrink tubing shall be installed over the soldered connections.

Controller cabinets shall be wired to provide output signals for the controller to the loop detector amplifiers so that the delay feature of the associated phase is inhibited during the green interval.

Outgoing traffic signal circuits shall be the same polarity as the line side of the power supply. The common return of signal circuits shall be the same polarity as the ground side of the power supply. The power supply shall be grounded to the ground bus of the controller cabinet. The ground bus, neutral bus, and logic ground bus in the cabinet shall be copper.

When the time-based coordination feature of the controller is used to establish a coordinated system with controllers operating fully actuated, the controller cabinet shall be wired to inhibit mainline through, right turn, and pedestrian detectors when coordination is not in free operation.

Transient protection shall be provided in traffic signal controller and master controller cabinets for the following:

- a. **Main AC power input:** Transient protection for the AC power input shall be connected on the load side of the main AC circuit breaker. The transient protection shall (1) withstand a 15,000-ampere surge current with an 8 by 20-microsecond wave form, 20 times at 3-minute intervals between surges, without damage to the suppressor; (2) limit the surge voltage to a 2,000-volt peak; and (3) limit follow current to an appropriate level to prevent tripping of the main circuit breaker of the cabinet or enclosure.
- b. **Interconnect cable and field wiring:** Transient suppression for field wiring shall be installed on the front of the back panel. Transient suppression for interconnect cable and field wiring, except loop detector lead-in cable, shall (1) clamp the surge voltage to a level no greater than twice the peak operating voltage of the circuit being protected and (2) withstand a surge current of 1,000 amperes with an 8 by 20-microsecond wave form, six times at 1-second intervals between surges, without damage to the suppressor.
- c. **Loop detector lead-in cable:** The panel shall be located on the right side near the front of the cabinet and above the level of the lowest shelf. A preemption test switch with necessary wiring shall be located on this panel. Transient suppression for loop detector lead-in cables shall not affect the operation of inductive vehicle loop detectors and shall (1) protect detector unit loop inputs against differential (between the loop lead) surges and against common mode (between loop leads and ground) surges, (2) clamp the surge voltage to 25 volts or less when subjected to repetitive 300-ampere surges, and (3) withstand repetitive 400-ampere surges with an 8 by 20-microsecond wave form without damage to the suppressor.

4. **Accessory and auxiliary equipment:** As a minimum, traffic signal controller cabinets shall be furnished with the following:
- a. removable, noncorrosive metal back panel (13-gage minimum) that shall incorporate a swing-down design to allow it to be placed in at least a 60-degree angle below the vertical position when the top attachment mechanisms are removed. The design shall use noncorrosive metal hinges or pins of adequate number and strength to support the back panel and attached equipment
  - b. removable, noncorrosive metal detector panel (13-gage minimum) at least 35 inches in length and 6 1/2 inches in width with two rows of barrier terminal blocks. Each row shall consist of 48 double-pole terminals rated at 4,000 volts r.m.s., 30 amps, and be able to accommodate up to 10-gage solid wire. The panel shall be wired in accordance with the following:
    - (1) 16 double-pole terminals for vehicle calls (2 per phase)
    - (2) 4 double-pole terminals for pedestrian calls (1 each for phase 2, 4, 6, and 8)
    - (3) 3 double-pole terminals for detector +115 VAC
    - (4) 3 double-pole terminals for detector AC Common
    - (5) 3 double-pole terminals for ground
    - (6) 3 double-pole terminals for detector logic ground
    - (7) 8 double-pole terminals for 115 VAC delay override
    - (8) 4 double-pole terminals each for phase 1, 3, 5, and 7 for vehicular detector field wiring
    - (9) 10 double-pole terminals each for phase 2, 4, 6, and 8 for vehicular detector field wiring
  - c. removable, noncorrosive metal auxiliary panel(s) (13-gage minimum) with terminals wired for auxiliary connector(s) functions
  - d. removable, noncorrosive metal detector test panel (13-gage minimum), readily accessible when the main cabinet door is opened, providing vehicle inputs through a momentary switch to each of the 8 phases and pedestrian inputs to phases 2, 4, 6, and 8
  - e. ground fault convenience receptacle

- f. removable, noncorrosive metal power panel (13-gage minimum) located on the right side near the front of the cabinet. A clear Plexiglass shield with openings for manual operation of breakers shall be installed over the panel with standoffs and thumbscrews.
- g. 2 circuit breakers. One circuit breaker, which shall be isolated from the power supply for the signal and control equipment, shall be rated at least 20 amps and shall operate the vent fan, ground fault convenience receptacle, and lamp. The other circuit breaker shall be rated at least 40 amps and shall operate all other equipment, including the signal load. Separate terminal strips shall be provided for each circuit breaker and an unfused terminal for the neutral side of the power supply line.
- h. screened and louvered vent designed to prevent rain entry, with a 14 by 20 by 1-inch standard furnace vent filter. The filter tray shall be sized to house and secure the filter in place. The screen shall be constructed from at least 0.031-inch aluminum with 1/8-inch diameter openings positioned on 3/16-inch staggered centers. The screen shall be placed on the inlet side of the filter and held in place by the filter or silicone adhesive.
- i. screened air exhaust opening under the top overhang
- j. thermostatically controlled vent fan with a screened guard in the top section of the cabinet with a capability of exhausting at least 100 CFM. The thermostat shall be adjustable from 80 degrees F to 130 degrees F. Degree markings shall be indicated on the thermostat in 10-degree increments.
- k. radio frequency interference filter rated at 50 amps
- l. transient protection devices
- m. dual-circuit flasher, 15 amp rating over the temperature range of -34 degrees C to +74 degrees C conforming to NEMA standards with an LED indicator for each circuit
- n. fluorescent lamp, ordering code #F20T12/D, and an on/off door switch located in the cabinet so that it will provide for the unobstructed illumination of controller timing adjustments. A toggle switch mounted on the cover behind the police panel, and a momentary switch operated by the door shall be connected in-line for operation of the lamp.
- o. 12-channel NEMA stand-alone conflict monitor with its own power supply and an LCD. The monitor shall have an internal

99-year real-time clock referenced to 60 Hz AC power line. Clock shall be easily set to the nearest second of the year from the front panel. A crystal oscillator shall be provided to maintain the accuracy of the clock to at least 0.005 percent (50PPM) when on standby power. Clock time and date shall be maintained for at least one year during periods of power loss. Automatic corrections shall be made for Daylight Saving Time.

In addition to NEMA requirements, the conflict monitor shall have user selectable features for monitoring simultaneous dual indications on a channel and controller amber clearance intervals. The intersection shall be placed in flashing operation if the controller amber clearance interval is less than a fixed minimum and when programmed dual indications occur simultaneously on a channel. If power loss occurs after a failure, the conflict monitor shall be capable of displaying, upon restoration of power, the indications on at the time of power loss. The conflict monitor shall log at least nine previous faults and ten power interruptions and restoration by date and time in non-volatile memory.

Conflict monitor shall have an auxiliary connector mounted on the front panel that will allow transfer of data to a printer. Connection of the conflict monitor to the printer shall be accomplished through the use of a cable with a DB-25 male connector on one end for connection to the printer and the appropriate connector on the other end for connection to the conflict monitor auxiliary connector. The Contractor shall furnish 2 cables to the Department. Upon command, current date and time, monitor configuration, and previous faults and power interruptions and restorations shall be printed in a usable format without disrupting normal monitor operation. Previous faults shall indicate channel indications on and time and date of fault occurrence.

The LCD shall have display indications in conformance with NEMA and the following changes and additions:

- (1) Four individual indications per channel displaying active red, yellow, green and walk inputs. Indications shall be displayed using the following symbology: R = red, Y = yellow, G = green and W = walk. Monitor shall be capable of displaying the indications simultaneously for all active inputs.
- (2) Amber clearance failure indication
- (3) Dual indication
- (4) Program card compatibility phases

- (5) Date, time and type of fault condition including channel indications on for logged faults
  - (6) Date and time for power interruptions and restorations
  - (7) Current date and time
- p. wired signal, pedestrian, and overlap load switch mounting bases (16) wired for the following from left to right: 8 phases, 4 overlaps, and pedestrian movement for phases 2, 4, 6, and 8
  - q. 12 solid-state signal load switches (signal and overlap) conforming to NEMA standards, each having LED indicators for active input and output circuits. The load switch shall have a 15-amp rating over the temperature range of -34 degrees C to +74 degrees C
  - r. 6 flash-transfer relays with a rating of 1/4 H.P. at 120 VAC; 30 AMP, 120/240 VAC; 20 AMP, 28 VDC
  - s. 1 or more field wiring terminal(s) for each light circuit plus 1 terminal for the common conductors, but not fewer than one for every four signal circuits. Signal common terminals shall be grounded to the cabinet.
  - t. 2 switches inside the main cabinet on the cover behind the police panel that provide the same functions as the switches in the police panel
  - u. removable, noncorrosive metal resistor panel (13-gage minimum) located on the left side near the bottom of the cabinet. The panel shall be of sufficient size to adequately mount four resistors. Resistors shall be mounted horizontally, one below the other, in the following order from top to bottom; phase 1, phase 3, phase 5 and phase 7.
- (e) **Signal Heads:** Signal head sections used in installing intersection control beacons and hazard identification beacons shall be the same as those described herein for standard traffic signal head sections.

Cast aluminum signal head sections shall be used for span wire installations, free-swinging mast arm installations, and pedestal-mounted installations that use only slipfitters. Cast aluminum or polycarbonate signal head sections may be used for all other installations.

1. **Traffic signal lamp wattages** shall be as follows: 60-watt lamps for 8-inch amber flashers, 100-watt lamps for all other 8-inch sections, 100-watt lamps for 12-inch amber flashers, and 150-watt lamps for all other 12-inch sections.

2. **Traffic signal backplates** shall be specifically manufactured for the type and brand of signal heads used to ensure proper fit with a border width of 5 inches and shall be without louvers and of one-piece construction with the exception of those for five-section cluster signal heads, which may be a maximum of five pieces.
3. **Standard traffic signal head sections** shall conform to the requirements of the ITE Standard for Vehicle Traffic Control Signal Heads and Section 238 and shall include cap visors.
4. **Selective view traffic signal head sections** shall conform to the requirements of Section 238, shall permit the visibility zone of the indication to be determined optically, and shall not require hoods or louvers. The projected indication shall be selectively visible or veiled within 15 degrees of the optical axis. No indication shall result from external illumination, nor shall one light unit illuminate another unit.

The optical system and materials shall be comprised of a lamp with a collar, an optical limiter-diffuser, and an objective lens. The lamp shall be a three-pronged sealed beam having an integral reflector with stippled cover and shall be coupled to the diffusing element with a collar that includes a specular inner surface. The diffusing element shall be discrete or integral with the convex surface of the optical limiter.

The optical limiter shall provide an accessible imaging surface at focus on the optical axis for objects 900 to 1,200 feet away and shall permit an effective veiling mast to be variously applied as determined by the desired visibility zone. The optical limiter shall be provided with a means for positive indexing and shall be composed of heat-resistant glass.

The objective lens shall be a high-resolution annular incremental lens hermetically sealed within a flat laminant of weather-resistant acrylic or an approved equal. The lens shall be symmetrical in outline and capable of being rotated to any 90-degree orientation about the optical axis without displacing the primary image.

The optical system shall accommodate the projection of diverse, selected indications to separate portions of the roadway such that only one indication will be simultaneously apparent to any viewer. The projected indication shall conform to ITE transmittance and chromaticity standards.

Die-cast aluminum parts shall have a chromate preparatory treatment. The exterior of the signal case, lamp housing, and mounting flanges shall be finished with high-quality baked enamel primer and finish paint. The lens holders and interior of the case shall be optical black.

The signal case and lens holders shall be predrilled for backplates and visors. Hinge and latch pins shall be stainless steel. Access openings shall be sealed with weather-resistant rubber gaskets.

The signal shall mount to a standard 1 1/2-inch traffic signal fitting as a single section, a multiple section face, or in combination with other signals. The signal section shall be provided with an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal plane while maintaining a common vertical axis through the couplers and mounting. The terminal connection shall permit external adjustment about the mounting axis in 5-degree increments. The signal shall be mountable with ordinary tools and capable of being serviced with no tools.

Attachments, such as visors, backplates, and adapters, shall conform and readily fasten to existing mounting surfaces without affecting the water and light integrity of the signal.

Lamp fixtures shall be comprised of a separately accessible housing and integral lamp support; an indexed ceramic socket; and a self-aligning, quick-release lamp retainer. Electrical connection between the case and lamp housing shall be accomplished with an interlock assembly that disconnects the lamp holder when opened. Each signal section shall include a covered terminal block for clip or screw attachment of lead wires. Concealed No. 18 AWG stranded and coded wires shall interconnect sections to permit field connection within any section.

Each signal section shall include an integral means of regulating its intensity between limits as a function of individual background illumination. Lamp intensity shall be at least 97 percent of the uncontrolled intensity at 1,000 footcandles and shall decrease to  $15 \pm 2$  percent of maximum at less than 1 footcandle. Response shall be essentially instantaneous and proportional to any detectable increase in illumination from darkness to 1,000 footcandles and damped for any decrease from 1,000 footcandles.

The intensity controller shall be comprised of an integrated directional light sensing and regulating device interposed between the lamp and wires. It shall be compatible with a 60-Hz input and responsive within the range of 105 to 135 volts. Output may be phase controlled, but the device shall provide a nominal terminal impedance of 1,200 ohms open circuit and a corresponding holding current.

The signal head shall be optically programmed in accordance with the manufacturer's recommendations.

5. **Pedestrian signal heads** shall conform to the requirements of ITE Standards for Pedestrian Traffic Control Signal Indications and the requirements of Section 238.

6. **Lane-use control signal heads** shall conform to the requirements of ITE Standards for Lane-Use Traffic Control Signal Heads and Section 238.
- (f) **Illuminated Traffic Control Signs:** Signs shall be square or rectangular weatherproof units. Only internal illumination shall be used. When illuminated, the message shall be white on an opaque background. The sign face or cover shall consist of a polycarbonate lens. The housing shall be sheet aluminum at least 0.125 inch in thickness finished with two coats of flat black paint.

The size and arrangement of letters forming the message shall conform to the requirements of the *Federal Standard Highway Signs Booklet* or an adaptation approved by the Engineer. When activated, the message shall be clearly readable at all times at a distance of 200 feet in all atmospheric conditions except dense fog. The message shall be controlled by a time clock or another type of actuation as specified on the plans. Signs shall illuminate instantly without a “warm-up” requirement or a continuously energized ballast. When signs are deenergized, the message shall not be readable.

(g) **Detectors:**

1. **Magnetic detectors** shall consist of a sensitive magnetic circuit housed in a lightweight metal cylinder approximately 2 inches in diameter, approximately 20 inches in length, and shall be equipped with two 35-foot (minimum) stranded leads.
2. **Magnetic detector amplifiers** shall be solid-state and properly connected to sensor(s) to produce, upon vehicle actuation, an output through a relay that has both normally closed and normally open circuits. A fail-safe design shall be incorporated so that a constant detection signal for control equipment will be provided in the event of a power loss. The unit shall be housed in a mechanically sound metal enclosure designed to allow stacking of multiple units having maximum dimensions of 3 inches in height, 6 inches in width, and 8 inches in depth. An 8-pin MS connector for making external detector connections, an adjustable sensitivity control, and a visual vehicle actuation indicator shall be provided on the front panel of the amplifier enclosure. The amplifier shall provide stable operation within an ambient temperature range of -30 degrees F to +135 degrees F when operating from a 120-volt, 60-Hz, single-phase AC power supply with a nominal power consumption of 5 watts or less. A fuse of a suitable ampere rating shall be provided to protect the power supply of the detector amplifier. Fuses shall be easily replaceable from the front panel.
3. **Inductive loop detectors** shall conform to the requirements of the performance characteristics required by NEMA TS-1.

The manufacturer of the loop detector amplifier shall provide a certification from an independent testing laboratory that the model furnished complies with NEMA Environmental Standards and Test Procedures.

Loop detector amplifiers shall be a single-channel, shelf-mounted, relay-output type with indicator lights on the front panel and delay and extension detection features. When the delay feature is used, it shall be inhibited during the green interval of its associated phase. The detector amplifier shall be adequately fused, and fuses shall be easily replaceable from the front panel.

4. **Pedestrian detectors** shall be pushbutton operated at low voltage (not more than 15 volts AC or 24 volts DC).

### 703.03—Procedures.

Equipment shall be installed so that it is ready for full operation.

- (a) **Prosecution of Work:** The Contractor shall not discontinue the operation of an existing signal without the approval of the Engineer. Requests for discontinuance shall be made at least 48 hours in advance.

While modifying or replacing existing traffic signals, the Contractor shall provide necessary traffic controls for maintenance of traffic, as approved by the Engineer. Traffic flow shall be maintained during the modification or replacement. Normal or routine maintenance that is not attributable to the Contractor's operations will remain the responsibility of the Department or local municipality.

When the Contractor begins modifying or replacing existing signal equipment or placing new signal equipment in operation, he shall maintain and repair the equipment until final acceptance. If the equipment malfunctions during the Contractor's working hours or during peak traffic hours as determined by the Engineer, the Contractor shall take immediate action to maintain the normal flow of traffic and make necessary repairs as expeditiously as possible that will cause the least interference with traffic.

The Contractor shall furnish the Engineer with the name and telephone number of the supervisory employee of his company who will be responsible for responding to repair calls during nonworking hours. If a signal malfunctions, the Contractor shall make necessary repairs within 4 hours from the time of notification. If the Contractor fails to make the repairs within 4 hours, the Department may make the repairs in accordance with Section 104. This shall in no way relieve the Contractor of his responsibility for maintaining and completing the work.

When replacing or modifying an existing coordinated signal system, the Contractor is not required to maintain the existing system coordination unless directed to do so by the Engineer.

- (b) **Equipment Color:** The color of metal equipment shall be obtained by applying two coats of paint. The color of plastic equipment shall be obtained by impregnating the color into the plastic. When painting of aluminum and galvanized metal equipment is required, the equipment surface shall be treated to ensure adherence of the paint. Signal head color shall be Federal Yellow except the inside of the visors shall be flat black. Backplates (both sides) and signal leveling attachments shall be flat black.
- (c) **Refurbishing Existing Equipment:** Existing equipment to be retained shall be cleaned. Existing metal equipment to be retained shall be repainted as specified herein.
- (d) **Mounting Controller Cabinets:** Pole-mounted controller cabinets shall be attached to metal poles or signal pedestals by means of brackets secured by encircling clamps made for the purpose and to wood poles by means of lag screws and plates bolted through the back of the cabinet or by encircling clamps made for the purpose.

Ground-mounted cabinets shall be installed on a concrete foundation.

- (e) **Installing Signal Heads:** At new or modified traffic signal installations, each signal head shall be covered with a durable, nontransparent cover upon installation. The Contractor shall maintain the cover until the signal is put into operation.

Housings shall be joined at the top and bottom in accordance with the manufacturer's specifications to form complete signals. Unused ends of sockets shall be closed with ornamental cap screws. Joints shall be rendered weatherproof by a suitable combination of lead and steel washers.

1. **Standard and selective view traffic signal heads** shall be installed so that there is at least 8 feet between lines drawn perpendicular to the center of any two adjacent signal heads that provide indications to the same approach. The Contractor shall verify the location and alignment of each signal head for orientation to its approach lane(s) prior to installing the signal conductor cable. If the location of the signal head designated on the plans is not oriented correctly with the applicable approach lane(s), the Contractor shall determine the proper location(s) and submit supportive data to the Engineer for review.

The bottom of the housing of a pedestal-mounted or bracket-mounted signal face adjacent to the pavement shall be at least 8 but not more than 15 feet above the sidewalk or, in the absence of a sidewalk, above the pavement grade at the center of the roadway.

Balance adjusters shall be installed with span wire hanger assemblies. Lock washers shall be used with nuts on the balance adjuster, and the vertical eyelet bolt shall have a cotter key inserted through a hole in the center of the bolt. The hole shall be located approximately two threads from the bottom of the bolt. The vertical eyelet bolt shall be secured from movement with a lock nut.

Serrated teeth on hanger assemblies shall be of the correct number and size to mate properly with the teeth on the signal heads.

The lowest point of the signal head assembly, including backplates and tether wire attachments, suspended over the roadway shall be at least 15 feet for mast arm installations and at least 16 feet for span wire installations above the pavement grade at the center of the roadway. The bottom of the signal head housing shall be not more than 19 feet above the pavement grade at the center of the roadway for mast arm and span wire installations.

2. **Pedestrian signal heads** shall be mounted with the bottom of the lower signal unit at least 7 but not more than 10 feet above the sidewalk and shall be placed in the line of vision of pedestrians using the applicable crosswalk. When mounted on the same support with vehicular signal indications, signal groupings shall be at least 1 foot apart. Pedestrian indications shall be below vehicular indications.
  3. **Lane-use control signal heads** shall be installed to operate in accordance with the *MUTCD*. The lowest point of the signal head assembly suspended above the roadway shall be in accordance with (e)1. herein.
  4. **Signal lamps** shall be installed in signal heads in accordance with the ITE Standard for Vehicle Traffic Control Signal Heads.
  5. **Backplates** shall be attached with bolts, washers, and lock nuts or self-tapping screws and washers. The number of bolts or self-tapping screws required shall be at least 8 for a 3-section signal head assembly, 10 for a 4-section assembly, and 12 for a 5-section assembly. Bolts, screws, and washers shall be of a noncorrosive metal or shall have a noncorrosive outside coating.
- (f) **Installing Illuminated Traffic Control Signs:** Illuminated signs used to control right or left turns shall be mounted directly over or adjacent to the affected traffic lane(s) at the height prescribed for standard traffic signals. When mounted with standard and selective view traffic signal indications, illuminated traffic control signs and signals shall be separated so as to prohibit physical contact.
- (g) **Installing Detectors:** The location of detectors shall not deviate more than  $\pm 2$  feet from the location(s) shown on the plans unless the Contract-

tor submits a detailed drawing showing the exact location of the detector(s) in question and secures the written approval of the Engineer. Detector lead-in cable shall be continuous and unspliced from the detector to the detector panel terminals.

Splices between loop or magnetic detector conductors and the lead-in conductors shall be allowed only in signal junction boxes. A separate splice kit shall be used for each lead-in cable. These splices shall be joined, made mechanically secure, and then tested electrically. When the mechanical connection has been shown to be electrically functional under operational conditions, it shall be soldered with a fusible metal or alloy. Each splice shall then be covered with one layer of half-lapped, 3/4-inch self-bonding rubber tape and one layer of half-lapped, 3/4-inch vinyl tape. The tape shall be installed so at least 3/4 inch of the insulation is covered by the tape. The splice shall then be installed in a splice kit.

Detector and detector lead-in cable shall be installed with the slack length coiled in the junction boxes. The coiled length shall be sufficient to allow the cables to extend at least 2 feet above the junction boxes.

Detector and detector lead-in cable jackets shall be permanently identified in the controller cabinet and junction boxes. Identifications shall be indicated on nonferrous metal tags or nylon tags attached to the cable with nylon cable ties. The identification shall be stamped or engraved on the metal tags and lettered with permanent ink on nylon tags. Identifications shall be legible and shall conform to the following:

- **Detector lead-in cable:** phase and location (lane and setback distance from stop line) of detector: e.g., 1 NB stop line left-turn lane loop; 2 SB 200 feet through lanes mag.; 6 NB stop line inside through-lane loop; 2 Ped NW Quad
  - **Detector cable:** phase and location of detector: e.g., 1 NB left-turn lane loop; 2 SB through-lane mag.; 6 NB inside through-lane loop; 6 NB outside through-lane loop
1. **Magnetic detectors:** Magnetic detectors shall be encased in heavy-wall PVC conduit 3 inches in diameter installed in a trench cut to a depth of 15 inches and shall be surrounded with at least 3 inches of sand. When approved by the Engineer, the sensing element, encased in PVC conduit, may be installed in a hole bored parallel to the surface and at the required depth.

Magnetic detector circuits shall not be run in the same cable sheath with conductors carrying signal power.

2. **Inductive loop detectors:** Slots shall be sawed into the pavement, cleaned with pressurized water at a minimum of 50 pounds per

square inch, and then dried with filtered compressed air before loop conductors are installed and sealed. One-inch lengths of PE foam backer rod shall be installed in the slot at slot intersection points and on 2-foot maximum centers between those points after installation of the loop conductors. The backer rod diameter shall be 1/2 inch for 3/8-inch slots, 5/8 inch for 1/2-inch slots, and 3/4 inch for 5/8-inch slots. Sealant shall conform to the requirements of Section 212. Loops shall be installed in the presence of the Engineer.

Loop detectors shall not be installed in pavement that has been open cut, repaired, or rebuilt in a manner where the pavement structure is not sound and continuous in the area of the proposed loop installation. When loop detectors are to be installed in existing pavement, the Contractor shall first field inspect the loop locations and advise the Engineer of any such locations that have been open cut, repaired, or rebuilt. The Engineer will direct the Contractor in locating the loop detectors.

A Megger reading of at least 100M ohms shall be obtained for each loop detector (cable and shield). This test shall be made at 500 volts immediately before the sealant is installed and again after the sealant has set at least 24 hours. Cable shall be disconnected from the detector amplifier during testing.

Loop cable shall be installed without damaging the cable or its insulation. Damaged cables shall be replaced at the Contractor's expense. Cable shall be installed with no kinks or curls and no straining or stretching of the insulation and shall be secured as deep in the slot as possible. When loop cable crosses pavement joints, an 8-inch section of flexible plastic sleeve shall be installed to prevent damage from pavement shifts. A blunt object, similar to a wooden paint stirrer, shall be used to seat the loop cable. The two ends of the loop conductor cable between the roadway loop and the junction box shall be twisted together, with approximately two turns per running foot.

The lead-in cable shield (drain wire) shall be connected to ground at the controller cabinet only. The lead-in cables shall have soldered on spade connectors for attachment to the detector panel terminals. Heat shrink tubing shall be installed over the soldered connections.

3. **Pedestrian detectors:** Pedestrian detectors shall be mounted on supports as indicated on the plans. Breakaway connectors shall be installed on conductor cables for pedestrian detectors on pedestal poles. Breakaway connectors shall be fused for the hot conductor and nonfused for the grounded conductor. The location of the breakaway connectors shall be in the hand hole of the pedestal pole.

(h) **Rigging Details:**

1. **Overhead span wire:** Where a 1/4-inch span wire terminates at a wood or steel pole, it shall be attached to a 5/8-inch thimbleye bolt and secured with two 2-bolt clamps. Where a 1/2-inch span wire terminates at a wood or steel pole, it shall be attached to a 3/4-inch thimbleye bolt and secured with two 3-bolt clamps.

Span wires shall be unspliced and unjointed and tightly drawn to the desired height and position while the pole is maintained in the vertical position.

Saddle clamps, strand connectors, and strain insulators shall be designed for the size of the span wire and shall meet or exceed the strength of the span wire.

Down guys shall be used on wood poles and shall be the same type of cable used in span wires. They shall be attached to the pole in the same manner and at the same height as span wires. Lateral guys placed over the roadway shall be strung to maintain a vertical clearance of at least 17 feet 6 inches. Lateral guys and down guys shall be tightly drawn in a manner to secure the pole while its vertical alignment is maintained. Metal or approved plastic gutters shall be installed on down guys. Sidewalk struts shall be provided where the vertical distance from the sidewalk to the down guy is less than 8 feet.

Integral messenger cable may be used for interconnect cable runs in lieu of span wire support. Signals, signs, or other equipment shall not be suspended from integral messenger cable.

Obstructions shall be bypassed by the use of special brackets or pole extensions.

2. **Tether wire:** Tether wire shall be unspliced and unjointed and attached to a pole by means of a 5/8-inch thimbleye bolt, a two-bolt clamp, and a guy sleeve. Tether wire shall be drawn in a manner to secure the attached signal head against movement caused by wind loads. Signals, signs, or other equipment shall not be suspended from tether wire.
- (i) **Testing Equipment:** After energizing the signal installation, the Contractor shall demonstrate to the Engineer that electrical components are in proper working order. Faulty electrical components shall be repaired or replaced by the Contractor at his expense.

Upon completion of electrical tests, the Contractor shall conduct a demonstration test of each signalized intersection for 30 continuous days. The Contractor shall provide personnel to fine-tune and correct deficien-

cies in traffic signal installation(s) during the 30-day test period at his own expense. If any portion of the signal installation(s) is replaced or repaired, the portion shall be subjected to an additional 30-day test immediately after replacement or repair.

Testing of the traffic signal system master controller and system coordination shall be conducted after completion of the demonstration test of each signalized intersection.

A Phase I test and debugging period of at least four consecutive calendar days shall begin after the system has been installed and approved by the Engineer. The test period shall conclude with a formal successful demonstration of the proper operation of system functions.

Upon successful completion of the Phase I test, the system shall undergo a Phase II operational test of at least 30 days. During this period, the system shall be programmed to provide on-line traffic control. The Phase II test will be considered complete and the system acceptable when all system functions demonstrate full compliance with the specifications. If failures occur, tests shall be stopped. After corrections are made, a new 30-day test shall commence.

Prior to final acceptance, the Contractor shall furnish the Department written certification that the system control equipment has been installed in accordance with the manufacturer's specifications.

#### **703.04—Measurement and Payment.**

**Master controllers** will be measured in units of each and will be paid for at the contract unit price per each. This price shall include timing data, timing implementation, training, controller cabinets, back panels, power panels, detector panels, auxiliary panels, circuit diagrams, manufacturer's instructions, relays, auxiliary equipment, flexible cables, grounding systems, transient protection devices, radio frequency interference filters, wiring, and fittings.

**Controllers** will be measured in units of each and will be paid for at the contract unit price per each. This price shall include timing data, timing implementation, training, controller cabinets, back panels, power panels, detector panels, auxiliary panels, police panels, thermostatically controlled fan units in the cabinet with a vent, flashers, local flasher switches, radio frequency interference filters, signal switches, main switches, police hand controls, conflict monitors, flasher relay assemblies, power relays, signal control assemblies, lamp receptacles and ground fault convenience receptacles, circuit diagrams, flexible cables, grounding systems, transient protection devices, and fittings.

**Traffic signal head sections** will be measured in units of each and will be paid for at the contract unit price per each. This price shall include mountings, lamps,

molded terminal blocks, visors, backplates, fittings, realignments, and optical adjustments.

**Pedestrian signal heads** will be measured in units of each and will be paid for at the contract unit price per each. This price shall include mountings, lamps, visors, fittings, and realignments.

**Detector amplifiers** will be measured in units of each and will be paid for at the contract unit price per each. This price shall include connecting cables and fittings.

**Magnetic detector sensing elements** will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the sensing element with leads, PVC conduit, trenching, backfilling, compacting, boring, sand, and repairing the pavement structure.

**Pedestrian pushbuttons** will be measured in units of each and will be paid for at the contract unit price per each. This price shall include fittings and sign(s).

**Flashers** for flashing beacons will be measured in units of each and will be paid for at the contract unit price per each. This price shall include cabinets, mounting hardware, transient protection devices, radio frequency interference filters, power panels, grounding systems, and fittings.

**Saw cuts** will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include cutting, cleaning, drilling, disposing of surplus material, backer rods, and loop sealant material.

**Hanger assemblies** will be measured in units of each and will be paid for at the contract unit price per each. This price shall include pipe, brackets, clamps, balance adjusters, tether wire attachments, leveling devices, and fittings.

**Illuminated traffic control signs** will be measured in units of each and will be paid for at the contract unit price per each. This price shall include enclosure cabinets, sign messages, lens, lamps, internal electrical wiring and components, louvers, mounting attachments, grounding systems, and fittings.

**Tether wire** will be measured in linear feet from connection point to connection point and will be paid for at the contract unit price per linear foot. This price shall include thimbleye bolt assemblies and fittings.

**Span wire** will be measured in linear feet, from connection point to connection point, and will be paid for at the contract unit price per linear foot. This price shall include thimbleye bolt assemblies, conductor cable supports, and fittings.

**Cable terminal enclosures** will be measured in units of each and will be paid for at the contract unit price per each. This price shall include weatherproof enclosures, foundations, terminals, terminal panels or racks, grounding systems, and fittings.

**Loop detector cable and lead-in cable** will be measured and paid for in accordance with the requirements of Section 700.05.

**Cleaning, painting, and grouting of existing equipment retained in signal modifications** will not be measured for separate payment but will be considered incidental to other items of work.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
Master controller	Each
Controller	Each
Traffic signal head section (Size and type)	Each
Pedestrian signal head (Standard)	Each
Detector amplifier (Type)	Each
Magnetic detector sensing element (Standard)	Each
Pedestrian pushbutton	Each
Flasher	Each
Saw cut	Linear foot
Hanger assembly (Standard, [ ]-way)	Each
Illuminated traffic control sign	Each
Tether wire (Size)	Linear foot
Span wire (Size)	Linear foot
Cable terminal enclosure (Standard)	Each

## **SECTION 704—PAVEMENT MARKINGS AND MARKERS**

### **704.01—Description.**

This work shall consist of establishing the location of pavement markings and installing pavement markings, pavement markers, and reflectorized material on specified pavements in accordance with these specifications, the *MUTCD* and as directed by the Engineer.

### **704.02—Materials.**

The Contractor shall use an approved inventory tracking system for all materials received from the manufacturer. Shipment of materials from such inventory shall be accompanied by the following certification:

Material shipped under this certification has been tested and approved by VDOT as indicated by laboratory test numbers listed hereon.

Signature and Title \_\_\_\_\_ Date \_\_\_\_\_