

CITY OF EDMOND
STANDARD SPECIFICATIONS FOR CONSTRUCTION

800.00 TRAFFIC CONTROL FACILITIES

801.00 LIGHTING AND SIGNALS

801.01 DESCRIPTION. This work consists of furnishing all labor, equipment, appliances and materials, and performing all operations in connection with the installation of lighting systems and traffic signal systems in accordance with these Specifications and the Plans, or as established by the Engineer.

All electrical work shall conform to the requirements of the National Electric Code (NEC) except where superseded by these Specifications.

The lighting system shall be complete with all necessary accessories for proper operation. Transformers, disconnecting devices, protective devices, luminaries, and all other equipment shall be coordinated to secure the required result.

The traffic signal system shall be complete with all necessary accessories for proper operation. Controllers, signal heads, detectors, push buttons, synchronizing devices, time clocks, and all other equipment shall be coordinated to secure the required result.

801.02 MATERIALS. Within 30 days after receiving notice to proceed, the Contractor shall submit five copies of a complete schedule of materials and equipment proposed for installation to the Engineer for review and approval. This schedule shall include catalog cuts, diagrams, drawings, and such other descriptive data as may be necessary to satisfy the Engineer that the requirements of the Specifications will be met.

Upon completion of the work on traffic signal systems, the Contractor shall deliver the manufacturer's instruction manual for the maintenance, timing, and operation of all traffic control equipment to the Engineer.

A complete wiring diagram of the signal system and components and a parts list sufficient for the ordering of any part of the equipment furnished shall be included with each controller.

Where galvanizing on hardware is specified, such galvanizing shall comply with AASHTO M 232, Class C coating.

The electrical and mechanical equipment furnished and used shall be new, standard, manufactured products. All units of the same class of equipment shall be products of a single manufacturer.

The Contractor shall supply guarantees and warranties as specified in Subsection 106.11.

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801.03 CONSTRUCTION METHODS.

- A. General.** The locations of the electrical energy supply shown on the Plans are approximate only. Exact locations will be determined in the field. The Contractor shall make the necessary arrangements with the serving utility to complete the service connections. The connection to the primary system will be made by The City of Edmond or an authorized representative.

The lighting electrical energy supply and circuits will be, unless otherwise specified, 60 cycle, 480 volt, single phase and multi-grounded neutral for multiple connection of luminaries, with automatic photoelectric control to turn the lights on at dusk and off at dawn. The 480 volt lighting circuits will each be supplied from a primary system through a distribution transformer and control equipment.

The traffic signal electrical energy supply and circuits will be, unless otherwise specified, 60-cycle, single-phase 120-volt power.

- B. Bonding and Grounding.** Conduit, poles and cabinets shall be mechanically and electrically secure to form a continuous system, and shall be effectively grounded. Bonding and grounding jumpers shall be minimum no. 10 AWG copper wire or better for all systems.

Grounding of poles shall be by means of a copper wire, minimum no. 8 AWG, securely attached to the pole and attached to the ground rod as shown on the Plans.

Grounding conductors of conduit and neutral at service location shall be minimum no. 6 AWG copper wire.

- C. Existing Traffic Signal Equipment Removal.** All existing traffic signal equipment shall be removed by the Contractor and stored at a site designated by the owner. Such equipment shall be removed with as little damage as possible. Poles shall be removed wholly; anchor bolts, protruding conduit and the like may be cut flush with the final ground level. Footings, pull boxes, and underground conduit are to remain in place. Wiring shall be removed from underground conduit.

Labor and equipment necessary to complete such removal shall be included in the contract unit price for other items unless otherwise provided for on the Plans.

Normally existing signal equipment shall not be removed or made wholly inoperative until the satisfactory completion of the 24-hour test period of the new equipment. Old equipment is to remain in at least a minimum operating condition until the new system is approved for continued use.

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- D. *Covering of Signal Indications.*** Prior to the placing of the new signal equipment into operation, all signal heads installed but not lighted, shall be completely covered with an all-weather bag with the exception of pedestrian WALK-DON'T WALK indications. At no time shall the new system and existing system be visible to traffic at the same time.
- E. *Testing.*** Equipment shall be tested in accordance with Section 805.

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802.00 ELECTRICAL CONDUIT

802.01 DESCRIPTION. This work shall consist of furnishing and installing all the electrical conduit, junction boxes, fittings, expansion devices, and miscellaneous hardware necessary to complete the electrical conduit system in accordance with these Specifications and the Plans. The location of the conduit, junction boxes and etc., as shown on the Plans, is diagrammatic and may be subject to adjustment as the Engineer may direct in order to conform to existing field conditions.

802.02 MATERIALS.

- A. *Conduits and Fittings.*** Conduits and fittings shall meet the requirements of section 709.
- B. *Junction Boxes.*** Junction boxes shall be of the size and type shown on the Plans and shall be furnished with gasket and cover. Oversized condulets may be used in lieu of junction boxes when installed in conjunction with exposed conduit systems if an adequate splicing chamber can be provided and when approved by the engineer. Condulets may not be used when the branch circuit is shown to be fused.

All materials furnished shall be new and of approved quality and workmanship.

802.03 CONSTRUCTION METHODS.

- A. *General.*** Conduit shall be installed in accordance with the codes and regulations listed in Section 801 and these Specifications, but if in conflict, the installation shall be carried out in compliance with the requirements herein stated and the details shown on the Plans. Conduit runs shall be made as directly as possible.

Conduit shall be of the minimum sizes shown on the Plans. The Contractor may, at his option and expense, use conduit of a larger size provided the larger size is used for the entire length of the run from outlet to outlet.

The ends of all conduits, whether shop or field cut, shall be reamed to remove burrs and rough edges. Cuts shall be made square and true so that the ends will butt together for the full circumference. Slip joints or running threads will not be permitted for coupling conduit. When a standard coupling cannot be used for coupling metal type conduit, an approved threaded union coupling shall be used. All couplings for metal type conduit shall be tightened until the ends of the conduits are brought together. No exposed threads will be permitted. Non-metallic type conduit connections shall be of the solvent weld type.

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Galvanized conduit surfaces which have been damaged to the extent that bare metal is exposed shall be re-galvanized, metalized or painted with an approved zinc dust-oxide paint.

All metal type conduit ends shall be threaded and shall be capped with standard pipe caps until wiring is started. When caps are removed, the threaded ends shall be provided with conduit bushings. Non-metallic type conduit ends shall be capped until wiring is started. All conduit installed for future use shall be capped, unless terminating in a junction box or other electrical enclosure.

Factory conduit bends shall be in accordance with requirements of the NEC. Where factory bends are not used, conduit shall be bent, without crimping or flattening, using the longest centerline radius practicable but not less than six times the inside diameter of the conduit.

Conduit installed in concrete pole bases, in structures, or pedestals, shall extend not more than 2 inches vertically above the footing. Conduit entering through the side of pull boxes shall extend not more than 2 inches inside the box wall and not be less than 4 inches above the bottom, and shall be sloped toward the top of the box to facilitate pulling of conductors. Conduit entering through the bottom of a pull box shall extend a minimum of 4 inches above the bottom and shall be located a minimum of 4 inches above the bottom and shall be located near the end walls to leave the major portion of the box clear.

Nipples shall be used to eliminate cutting and threading where short lengths of conduit are required. No conductor shall be installed in the conduit system until all other work that might damage the conductors has been completed.

Existing underground conduit to be incorporated into a new system shall be cleaned and blown out with compressed air.

B. *Pushed or Bored Conduit.* The conduit shall be placed under existing pavement by approved pushing or boring methods. The pavement shall not be disturbed without permission from the Engineer. Pushing or boring pits shall be kept at least 2 feet clear of the edge of any type of surfaced area whenever possible. Use of water will not be permitted. Pits to be left overnight shall be covered with substantial planking and marked in a manner approved by the Engineer.

All pushed conduits shall be rigid metal. Bored conduit may be rigid metal or non-metallic. For rigid non-metallic type conduit a hole larger than the conduit shall be pre-drilled and the conduit installed by hand.

Unless otherwise shown, conduits bored or pushed shall be installed a minimum depth of 30 inches below top of ground line.

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Where conduit passes under a surfaced area, an "X" shall be cut in the curb and/or surfacing above the conduit crossings for future relocating purposes.

C. *Trenched Conduit and Backfilling.* Conduit installed in a trench shall be of the type specified on the Plans. Trenches shall be excavated to such depth as necessary to provide for 30 inches minimum cover over the conduit, unless otherwise specified.

The trenches shall not be excavated wider than necessary for the proper installation of the electrical conduits or cables. Excavating shall not be performed until immediately before installation of conduit. The material from the excavation shall be placed in a position where the least damage and obstruction to vehicular and pedestrian traffic and the least interference with the surface drainage will occur.

All surplus excavated material shall be disposed of by the Contractor, in a manner approved by the Engineer.

When rock is encountered during trenching and the required trench depth cannot be attained, the trench depth or location may be altered at the discretion of the Engineer. The minimum trench depth shall be 12 inches.

Cinders, broken concrete, or other hard or abrasive materials will not be permitted in backfilling. The trench shall be free of such materials before the conduit is placed. Conduit shall not be placed prior to inspection of the trench by the Engineer. All trenches shall be backfilled with acceptable material as soon as possible after installation of conduit. Backfill material shall be deposited in the trench in layers not to exceed 6 inches in depth. The first layer shall be free of rocks and compacted, and each successive layer shall be compacted before the next layer is placed. Backfill shall be compacted to not less than 95 percent standard density in accordance with Subsection 106.03.

All surfaced areas, base materials and sodded areas disturbed by the Contractor shall be reconstructed and/or replaced with materials of equal or better quality at the expense of the Contractor and to the satisfaction of the Engineer.

Whenever a part of an existing concrete sidewalk or driveway is broken or damaged, the entire square or slab shall be removed unless otherwise specified by the Engineer, and the concrete reconstructed as above specified. Pavement removal shall be in accordance with Section 619.

D. *Exposed Conduit.* Conduit to be installed on the surface of structures, poles, or other exposed locations shall be rigid metal type unless otherwise specified.

Conduit which is surface-mounted shall be run straight and true, horizontal or vertical on the surface of the structure or pole and shall be supported at intervals of not more than 5 feet, unless otherwise specified. The supports

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shall consist of galvanized malleable iron conduit clamps and bolts with expansion shield anchor devices approved by the Engineer. Lag or machine bolt shields and percussion driven anchors in concrete or masonry will not be accepted.

Conduit attached to structural steel members shall be attached with approved supporting devices.

E. Conduit in Concrete Structures. Conduit installed in concrete structures shall be rigid metal type, unless otherwise specified. An expansion device of the type and size shown on the Plans shall be installed when the conduit crosses an expansion joint in the structure.

Junction boxes installed in or on structures shall be of the size and type shown on the Plans.

802.04 METHOD OF MEASUREMENT. Electrical conduit of the size and type specified will be measured by the linear foot along the centerline of the installed conduit from end to end, and shall include all flexible steel conduit, fittings, outlets, entrance caps, pull wires, condulets, expansion devices, and other miscellaneous hardware necessary to complete the conduit system. Each size and type of conduit shall constitute a separate pay item, unless otherwise provided. Unless otherwise provided, trenching and backfilling will not be measured for payment. Junction boxes installed in structures shall be measured by each unit installed, if so specified.

802.05 BASIS OF PAYMENT. Accepted quantities of electrical conduit, measured as provided above, will be paid for at the contract unit price for:

(A)	Galvanized Steel Electrical Conduit	Lin. Ft.
(B)	Plastic Conduit	Lin. Ft.
(C)	Aluminum Conduit	Lin. Ft.
(D)	Junction Box	Ea.

which shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

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803.00 PULL BOXES

803.01 DESCRIPTION. This work shall consist of furnishing materials and installing the pull boxes in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

803.02 MATERIALS. Materials used shall meet the requirements specified in the following Subsections of Section 700 – Materials.

Concrete Pull Boxes	739.01
Plastic Pull Boxes	739.02

803.03 CONSTRUCTION METHODS.

A. General. Pull boxes shall be of the sizes shown on the Plans and as herein specified. The pull box locations may be revised to fit existing field conditions or to better facilitate the installation of the conduit system with approval of the Engineer.

The tops of pull boxes installed in the sidewalks or other surfaced areas shall be flush with the finished surface. When practical, pull boxes shown in the vicinity of curbs shall be placed adjacent to the back of the curb and flush with the top of the curb. Tops of pull boxes shall be flush with top of ground or no greater than one inch above the ground. All pull boxes shall be installed with concrete aprons unless installed in a surfaced area or otherwise specified by the Engineer. Aprons will be included in the cost of pull boxes.

All pull boxes shall be installed on a bed of crushed rock as shown on the Plans.

Conduits entering pull boxes shall be installed as shown on the Plans and in accordance with Section 802.

When called for on the Plans, pull box extensions shall be provided. The extensions shall be of the same material as the pull box and shall be attached to the pull box in a manner that will maintain the required depth without separation of the assembly.

B. Cover and Markings. Pull box covers shall be marked with the appropriate legend. The letters shall be between one and three inches tall. The legend shall be cast with the cover and shall be clearly defined, of uniform depth or height and placed parallel to one side of the cover. The words "High Voltage" shall be added when the conductor voltage is greater than 600 volts.

The cover shall be equipped with a recessed molded lifting eye and recess hold down bolts. The cover shall have a nonskid surface.

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C. Ground Rod. If specified, a copperweld ground rod shall be installed in accordance with the details and at the locations shown on the Plans.

803.04 METHOD OF MEASUREMENT. The pull boxes of the size and type specified will be measured by each unit installed. Each pull box unit shall include cover, extension, ground rod, concrete apron, crushed rock, excavation, and backfilling, necessary to construct and install pull boxes as shown on the Plans.

803.05 BASIS OF PAYMENT. Accepted pull boxes, measured as provided above, will be paid for at the contract unit price for:

Pull Box	Ea.
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which shall be full compensation for furnishing all materials, equipment, labor and incidentals required to complete the work as specified.

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804.00 CONCRETE FOOTINGS

804.01 DESCRIPTION. This work shall consist of furnishing materials and installing concrete footings for traffic control devices in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

804.02 MATERIALS. Materials used shall meet the requirements specified in the following sections of Section 700 – Materials and AASHTO Specifications.

Portland Cement Concrete, Class A	701
Reinforcing Steel	723
Electrical Conduit	709
Anchor Bolts and Nuts	AASHTO M 183
Galvanizing (Bolts, Nuts & Washers)	AASHTO M 232

840.03 CONSTRUCTION METHODS.

A. General. Concrete footings constructed in accordance with Section 509 shall rest on firm ground. They shall be constructed in place as required on the Plans and to the grade established by the Engineer. When an obstruction prevents the construction of a footing at the planned location the Contractor shall construct the footing at the location established by the Engineer.

The footing shown on the Plans may be modified if conditions require. Such modification, if ordered by the Engineer, will be paid for according to Subsection 109.05 or by the adjusted quantities of materials required; i.e., concrete and reinforcing steel.

B. Anchor Bolts. Anchor bolts shall be of the size and quantity shown on the Plans. They shall be accurately and securely located in the footing by means of a template. Anchor bolts shall have the top exposed portion plus 6 inches galvanized and threaded as shown on the Plans. Each anchor bolt shall be supplied complete with galvanized hex head nuts and washers as shown on the Plans. Welding shall not be permitted on any portion of the body of the anchor bolt.

C. Conduits. When it is required that conduit be installed as part of the footing, it shall be of the quantity, size and type as shown on the Plans. Conduit couplings shall be located at least 6 inches from the face of the footing. The conduit required in the footing will be paid for in the cost of other materials in the footing.

D. Ground Rod. If required, the copperweld ground rod shall be of the size shown in the Plans.

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E. Poles or Posts. Poles or posts shall not be erected until the foundation has set at least 72 hours unless the poles or posts are set directly in the footing.

When the footing has been completed, the surrounding area shall be restored to an acceptable appearance.

804.04 METHOD OF MEASUREMENT. Concrete footings of various sizes and shapes will be measured by the cubic yards of concrete and pounds of reinforcing steel required. The footing unit shall also include anchor bolts, nuts, washers, ground rod, conduit, all labor, tools, equipment, excavation, backfilling and incidental work necessary to construct the footing as shown on the Plans.

804.05 BASIS OF PAYMENT. Accepted concrete footings, measured as provided above, will be paid for at the contract unit price for:

Structural Concrete	Cu. Yd.
Reinforcing Steel	Lb.

which shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

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805.00 ELECTRICAL-MECHANICAL PERFORMANCE AND OPERATIONAL TESTS

805.01 DESCRIPTION. This work shall consist of furnishing all the necessary equipment, tools, and labor required to perform the tests specified within this Specification or as directed by the Engineer.

805.02 EQUIPMENT. The Contractor shall furnish all the necessary specialized test equipment, tools, electrical diagrams and labor required to perform the tests specified.

805.03 CONSTRUCTION METHODS.

A. General. The Contractor shall notify the Engineer not less than 48 hours prior to the beginning of the testing procedures. The Engineer shall coordinate with appropriate agencies for testing procedures.

B. Electrical Field Testing. Prior to the start of functional testing, the Contractor shall perform the following tests on all traffic signal and lighting circuits, in the presence of the Engineer, and the written results shall be included in the project file.

1. Each circuit shall be tested for continuity.
2. Each circuit shall be tested for grounds.
3. Ground rods, after installation, shall not have a resistance to ground in excess of 25 ohms.
4. An insulation resistance test at 50 volts DC shall be made on each circuit between the circuit and ground. The insulation resistance shall not be less than 10 megohms on all circuits.

The insulation resistance test shall not be performed on magnetometer detector devices. Splices in the conduit or junction box adjacent to the magnetometer shall not be made prior to performing the test on the lead-in conductors between said splices and the controller cabinet field terminals.

C. Electrical Functional Tests. The Contractor shall notify the Engineer at least 24 hours in advance of commencing the functional tests of a traffic signal system, in order that adequate precautions may be taken with respect to traffic service on the street system. Where traffic is being maintained through the project, every effort should be made to insure the safe movement of vehicles during this testing period. At no time shall the new system and an existing system be in operation at the same time.

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Lighting systems, both conventional and high mast, and traffic signal systems shall be operated for a 24-hour continuous period, to determine that all parts of the system are functioning properly. The electrical system shall be put into service and patrolled immediately to ascertain if there are any defects. The system shall be inspected at intervals established by the Engineer during the test period. At some time during this test all safety switches shall be thrown to check their operation. All photoelectric controllers shall be switched from auto to manual and back to auto, sometime during the night time portion of the test to observe the action of the photoelectric controller.

At the end of the 24 hours of continuous operation, the complete electrical system shall again be inspected to see that everything is operating normally and prove to the satisfaction of the Engineer that all fixtures and equipment have been properly installed and are in operating condition.

D. *Mechanical Test.* Following the successful completion of the 24-hour functional test, all high mast lighting systems shall be allowed to operate normally for six days. During these six days the system shall be observed at night time for any defects in the luminaire or lamps. The Contractor shall demonstrate to the Engineer that each lowering device assembly is functioning properly by completing one lower and raise cycle on each assembly.

E. *Defects.* The above tests are to show that the luminaries, lamps, wiring, controllers, and related equipment have been properly installed and are in satisfactory operating condition. Any defects shall be corrected to the satisfaction of the Engineer.

805.05 METHOD OF MEASUREMENT. The tests specified will not be measured for payment. All costs of performing these tests shall be included in other items of work.

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806.00 POLES AND MAST ARMS

806.01 DESCRIPTION. This Work shall consist of furnishing materials and installing poles, mast arms and pedestal poles for traffic signals, and lighting luminaries in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

806.02 MATERIALS. Materials shall meet the requirements specified in AASHTO Standard Specifications for Structural Supports of Highway Signs, Luminaries and Traffic Signals, and Section 700 of these Specifications.

806.03 CONSTRUCTION METHODS.

A. General. The design of the poles and mast arms shall be the responsibility of the manufacturer. The poles and mast arms shall be designed for a minimum of 80 MPH wind velocity and shall meet all other design requirements of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals.

Calculated stresses from design loading on poles and arms shall not exceed 50,000 pounds per square inch or 85 percent of ASTM yield strength, whichever is smaller. Certification shall be required that the material in poles meets the applicable ASTM specification for stress range the poles are designed to operate within. Minimum thickness of traffic signal steel poles and mast arms materials shall be 7-gauge.

The manufacturer shall submit shop and design drawings, and calculations in accordance with Subsection 105.02.

Mast arms may be mounted to the pole prior to erection of the pole. Care shall be taken not to damage the pole, mast arm or finish during erection. If the finish is damaged, it shall be repaired at the Contractor's expense in a manner approved by the Engineer.

Anchor base poles shall be leveled with nuts or shims. If double nut leveling is used, the space between the concrete foundation and the pole base shall be filled with a non-shrink grout.

All structural castings shall be cast in permanent molds.

B. Poles. The minimal mounting height of the luminaire or traffic signal shall be as shown on the Plans. All poles, except pedestal poles, shall be uniformly tapered from bottom to top and may be either round or multi-sided. Pedestal poles may be without taper. The pole shall be straight and centered on its longitudinal axis. Each pole shall be furnished with a reinforced handhole and weatherproof cover, unless otherwise specified. A removable pole cap shall be

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installed on each shaft, except pedestal poles. All metallic poles shall be provided with a grounding connection inside the base of the shaft and shall be grounded as shown on the Plans. Anchor bases may be either cast or structural plate.

C. Mast Arms. The mast arm shall be of the length shown on the Plans.

Luminaire mast arms shall be designed to support the weight of a 75 pound luminaire with a projected area of 3.3 square feet, and shall provide a smooth raceway for the wiring, and shall be supplied with a slip fitter tenon. Traffic signal mast arms shall be designed to support the required signal heads, as shown on the Plans.

806.04 METHOD OF MEASUREMENT. Poles and mast arms or pedestal poles of various types, sizes and lengths will be measured by each unit installed.

806.05 BASIS OF PAYMENT. The accepted poles and mast arms, measured as provided above, will be paid for at the contract unit price for:

- | | | |
|-----|-------------------|-----|
| (A) | Pole and Mast Arm | Ea. |
| (B) | Pedestal Pole | Ea. |

which shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as shown on the Plans and these Specifications.

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809.00 LUMINARIES

809.01 DESCRIPTION. This work shall consist of furnishing materials and installing roadway luminaries of various sizes and types in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

809.02 MATERIALS. All materials furnished, fabricated, assembled or installed under these Specifications shall be in strict accordance with the details shown on the Plans. The luminaries shall consist of a housing, ballast, reflector, refractor and lamp of the type and lumen rating specified on the Plans.

The luminaries furnished by the manufacturer shall meet IES standards for the size and type of luminaire specified on the Plans. The manufacturer shall provide photometric test data for each size and type of luminaire to be installed certified to be conducted in accordance with testing procedures approved by IES.

809.04 CONSTRUCTION METHODS. The installation of the luminaries shall be carried out in conformance with the details shown on the Plans.

If specified on the Plans, the luminaries shall be equipped with a cut-off visor.

809.05 METHOD OF MEASUREMENT. Accepted luminaries, measured as provided above, will be paid for at the contract unit price for:

(A) Roadway Luminaire	Ea.
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which shall be full compensation for furnishing all materials, equipment, labor and incidentals required to complete the work as specified.

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825.00 VEHICLE ACTUATED SOLID STATE TRAFFIC SIGNAL CONTROLLERS

825.01 DESCRIPTION. These Specifications and the latest revision of the NEMA (National Electrical Manufacturer's Association) standard specification describe the design and general requirements for a controller assembly which uses solid state digital circuitry (integrated or individual components) in modular type construction in the controller unit.

The controller unit when combined with the required modules shall be capable of providing full vehicle actuated control for any number of phases or movements as specified. The controller when used in minimum capacity shall be capable of providing a two-phase operation with one actuated phase and one non-actuated. All standard modules from one manufacturer and type equipment shall be interchangeable in the same manufacturer and type of mounting frame, so that logic and phase modules may be added or replaced to provide the movements required within the limits of the controller unit.

Functions provided by the controller unit shall be in accordance with the Plans and Specifications.

825.02 MATERIALS.

A. Modules. Each module shall be connected by means of an integral keyed plug-in connector to the master board or mounting frame. No connecting harness or wiring will be permitted other than programming connections on the mounting frame plug-ins.

Each module shall be fastened to the mounting frame by means of a captive nut and thumb screw arrangement or some other suitable latching arrangement. Also, each module and associated circuitry shall be removable from the front of the controller without the use of any special tools.

All timing circuits shall consist entirely of integrated and/or solid state digital electronic circuitry for timing. Vacuum tubes, gas tubes, relays, stepping switches and other assemblies with moving parts will not be allowed. Positive acting switches, program pins and/or keyboard units shall be used for control settings.

Each phase module shall consist of a printed circuit board with associated components, and a face plate having as a minimum the following function switches: Pedestrian recall, vehicle recall, locking, and non-locking switches. Switches provided by the manufacturer in addition to those mentioned above will be acceptable.

Each controller shall be equipped with a group of indicator lamps showing the status of the controller unit. The controller shall be capable of displaying a minimum of indicator lights on the front panel as follows:

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RING 1 AND 2 STATUS

1	Phase On (Per Phase)
2	Phase Next (Per Phase)
3	Vehicle Memory (Per Phase)
4	Max 2 (One Per Ring)
5	Pedestrian Memory (One Per Phase)
6	Max/Force-Off (Per Ring)
7	Vehicle Recall (Per Phase)
8	Pedestrian Recall (Per Phase)
9	Locking Non-locking (One Per Ring)
10	Gap Termination (One Per Ring)

The indicator lamps to be furnished shall be the light emitting diode type with a minimum rated operating life of 100,000 hours or as approved.

The circuit reference symbols for each component shall be clearly marked on the circuit board and all electrical components shall be standard production type and readily identifiable and available from industrial electronic suppliers.

Combining circuitry of two or more component parts into one module so that each individual component part cannot be serviced or replaced individually will not be acceptable. Standard production hybrid and/or integrated circuit blocks which are commercially available and replaceable are acceptable.

The design life of all components shall not be less than 5 years based on 24 hours a day operating conditions in their respective circuit applications.

Each module, together with its associated switches and switch functions, control functions and indicator lights and all mounting frame openings, shall be properly identified and marked on the front panels for ease in maintenance and adjustment. All dial knobs and switches shall be color-coded and/or labeled providing quick identification and ease of association with sequence timings or phases.

All components shall be amply de-rated with regard to heat dissipating capacity and rated voltages, such that under operating conditions of maximum ambient temperature and maximum applied voltage, a significant shortening of life or shift in values shall not occur.

Module functions shall be accomplished through the use of solid state digital electronic circuitry. No electro-mechanical devices, such as: camshafts, rotary stepping or line switches, shall be used for switching functions.

Where good design practices indicate a need, properly designed and located heat sinks shall be used to insure maximum life and efficiency of components.

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Signal light circuits shall be controlled externally to each solid-state controller unit by three-circuit, solid-state, load-switching devices which shall be plug-in mounted to a base located at the lower part of the controller cabinet. The solid-state, load-switching circuits shall each have a minimum rating of ten amperes at 120 volts, 60-cycle, single-phase, alternating current at 160° F and zero-point switching. Each load-switching circuit shall be furnished with a handle or a gripping device for removal. An indicator light for each circuit shall be provided in each load switch. The indicator light shall be on when a "true" input to the load switch is present. The load switch, when plugged in, shall be capable of supporting itself firmly in place. Vehicle and pedestrian load switches shall be interchangeable.

The timing of any interval or portion of any interval shall not change by more than + 0.5 percent of its set operating value due to changes in the ambient temperature between the limits of -30° F to 160° F. All modules other than those used in the mounting frame or accessory frames shall be encased in a one-piece, lightweight aluminum housing which shall be readily removed, exposing the components for inspection and maintenance.

The copper track printed circuit board shall be epoxy-filled woven glass coated with a 2 ounce per square foot copper coating before etching. Intercomponent connections shall be made utilizing the latest military approved "wave soldering" or "dip soldering" techniques. Printed circuit design shall be such that components may be removed and replaced without permanent damage to the board or tracks. Printed circuit boards shall be permanently marked to facilitate identification and servicing. A pictorial diagram shall be provided in the maintenance manual for all controller units showing physical location and identification of each component. All modules shall be provided with gold-plated mating contacts.

Schematic drawings with all voltage measurements and wave shapes, where appropriate, functional descriptions and testing procedure shall be well-defined and illustrated in accompanying manuals for each module or accessory item contained in the controller cabinet.

Basic range of interval timing adjustments for each phase module shall be as follows:

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INTERVALS	SECONDS	RANGE INCREMENTS
Initial	0 – 30	1.0
Extension (gap)	0 – 9.9	0.1
Maximum	0 – 99	1.0
Yellow clearance	0 – 9.9	0.1
Red clearance	0 – 9.9	0.1
Walk	0 – 30	1.0
Pedestrian clearance	0 – 30	1.0
Minimum green (semi operation)	0 – 99	1.0
Minimum red	0 – 6	0.1

B. Power. Electrical connections from the controller to the outgoing and incoming circuits shall be made by inserting a multi-terminal plug (MS Type) into the associated plug receptacle incorporated in the mounting frame or power supply panel. The controller unit shall be replaceable with a similar unit without the necessity of disconnecting and reconnecting any individual wires.

The controller assembly shall be designed to operate at 120 volts, 60-cycle single-phase alternating current + 15 percent voltage.

During a supply voltage interruption not exceeding 0.5 second duration, the solid state digital controller assembly shall continue in cycle operation and shall retain all actuations registered prior to the interruption. Following a supply voltage interruption exceeding 0.5 seconds duration, signal operations shall begin in the programmed start interval and calls shall be place on all phases.

The power supply unit shall be designed to supply the necessary power for the controller unit.

A thyrector unit or equally suitable device shall be used to protect the controller from line voltage surges and transient voltages.

C. Mounting Frame. Each controller unit shall be completely enclosed in a sheet metal case which serves as a mounting frame.

The case shall be designed to provide convenient access to the entire interior assembly and permit easy removal of printed circuit boards and modules with minimum use of tools. The mounting frame shall be equipped with sliding ways and receptacles to receive the modules without the use of any connecting harness or wiring except for programming on the mounting frame. Similar type plug-in assemblies shall be mechanically and electrically interchangeable between controller units of the same manufacture and type. Dissimilar units or non-compatible units shall be keyed to prevent any erroneous insertion into

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the mounting frame. The mounting frame shall contain the controller unit, power supply, all timing equipment, phase modules and sequencing units.

On a traffic signal project where it is planned to expand the control system in the future to an increased number of phase modules, the Plans may specify a larger mounting frame to accommodate this expansion. The cabinet and controller shall be wired and the number of load switch receptacles shall be provided for this expansion as shown on the Plans.

D. *Signal Conflict Monitor.* A solid-state monitoring device shall be installed in each solid-state digital traffic signal controller assembly. The conflict monitor shall meet the latest NEMA (National Electrical Manufacturer's Association) Standard Specifications, Part 6 for 3-, 6-, and 23-channel monitors. In the event of conflicting green signal indications (vehicular or pedestrian or both), the flashing operation shall lock-in and shall release only upon operation of a reset switch. All logic voltage power supplies shall be monitored and, if any voltage drops to a level where equipment does not work properly, the signal shall go into flashing operation.

E. *Controller Assembly Cabinet and Wiring.* The controller unit and all associated equipment shall be furnished completely housed in a sturdy aluminum cabinet. The cabinet shall have no sharp edges, corners or projections. The size of the cabinet shall be such as to provide ample space for housing the controller and all of the associated electrical and auxiliary devices which are to be furnished with it as specified on the Plans. A hinged door shall be provided permitting complete access to the interior of the cabinet. The door shall be sealed access to the interior of the cabinet. The door shall be sealed by neoprene gasketing material making the cabinet weatherproof.

The door shall be provided with a Corbin #2 lock and two keys. Pin for the door hinges shall be of non-corroding material.

The cabinet door shall be provided with a door catch that shall stop the door openings at 90 and 180 degrees + 10 degrees and will hold the door open securely until released.

At the lower part of the cabinet door a louvered vent system shall be furnished with a fiberglass air filter. This filter shall be secured to the door in such a way that it will permit the fan to pass the volume of air through the filter and not the fan to pass the volume of air through the filter and not around it. A thermostatically-controlled ventilating fan shall be furnished that shall have the capacity of moving at least 100 cubic feet of air per minute. The thermostatic controller shall be manually adjustable between 90° F and 150° F and shall automatically turn on and off within + 20° at the manual setting.

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Receptacles for relays and shelves below all removable control equipment, switches, fuses, circuit breakers, and all other equipment shall be identified below each item with a permanent printed label.

All terminals shall be permanently identified in accordance with the cabinet wiring diagram. Where through panel solder lugs or other suitable connectors are used, both sides of the panel shall have the terminals properly identified. Identification shall be permanently attached and as close to the terminal strip as possible and shall not be affixed to any part which is easily removable from the terminal block panel.

Each input and output function shall be distinctly identified with no obstructions, at each terminal point in the cabinet, either by number or function terminology. The same identification shall be used consistently on the cabinet wiring diagrams.

Each load switch socket shall be identified by phase number and overlap number as applies. No cabinet equipment may obstruct these identifications.

Each flash transfer base and power relay base shall be properly identified with no possible obstructions.

Each harness within the cabinet shall be distinctly identified on the connector end.

The flasher socket shall be distinctly identified with no possible obstructions.

All other sockets needed within the cabinet to fulfill the minimum requirements of the Plans, or attachments thereof, shall be distinctly identified.

Except where soldered, all wires shall be provided with lugs or other approved terminal fittings for attachment to binding posts. Insulation parts and wire insulation shall be of suitable material and insulated for a minimum of 600 volts.

The cabinet back panel shall either have all of the wiring on its front, or the wiring shall be readily accessible by means of a hinge enabling the back panel to swing down or sideways. Readily accessible shall mean that it shall be possible to gain full access to inspect or modify the wiring in less than 2 minutes by the use of simple tools. If the wiring is on the back of the back panel, the panel and wiring shall be designed so as to prevent the wiring from being pinched or chafed when the panel is placed in its normal operation position after a change in wiring is made. If a side panel with through-panel solder lugs or other suitable connectors is provided, both sides shall also be readily accessible as directed above.

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Wall-mounted auxiliary equipment and wiring shall be installed on removable panels. Plug-in equipment shall be removable from receptacles without removing any other equipment.

Machine screws and bolts shall not protrude beyond the outside wall of the cabinet.

Substantial shelves or brackets approved by the Engineer shall be provided to support controller unit and auxiliary equipment.

All solid-state digital traffic signal controller assemblies shall be furnished with a detector and pedestrian test switch panel. The switches shall be of the push button type and shall be installed and wired to the controller unit so that calls can be placed on each vehicle and pedestrian phase. This panel shall be so designed to be mounted approximately 4 to 6 inches from the top of the door and installed on the inside of the Controller cabinet door.

When an intersection display panel is specified it shall display a graphical representation of the intersection with display lights appropriately located and wired to indicate vehicle movements having the right-of-way. This display panel shall be mounted on the inside of the cabinet door below the detector switch panel. The controller assembly shall be furnished with a solid-state flasher conforming to Section 827.

There shall be an auxiliary police door provided in the main door with a standard police lock and two keys.

The panel behind the auxiliary police door shall contain the following switches:

1. Two-position switch – Auto and Flashing
2. Two-position switch – on and off

3. Phone type receptacle for manual control

On the inside of the controller cabinet door the following switches shall be furnished:

1. Two-position switch – Auto and Flashing
2. Three-position switch
 - a. Flashing and Stop Time – on
 - b. Off position
 - c. Stop Time position on

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3. Two-position switch – on and off
4. Two Refrigeration-Type Switches
 - a. Cabinet Light
 - b. Indicator Lights on Controller

A convenience outlet and a fluorescent trouble light shall be furnished in the controller cabinet. The light shall be placed near the top of the cabinet above the door opening.

As a minimum, the following items shall be a part of the cabinet wiring:

1. A terminal with insulated fuse receptacle and fuse for power supply line input.
2. A terminal unfused for the neutral side of power supply line input.
3. Terminals for conductors of signal light cable; one for each signal output circuit specified plus future required terminals to maximum capable function of the controller assembly.
4. One or more terminals for the common conductors on signal loads.
5. Terminals for all detector cables as required for maximum functional needs.
6. Terminals for all pedestrian push-button cables as required by maximum functional needs.

All terminal blocks shall be rated 600 volts, minimum, alternating current and shall be provided with nickel, silver, or cadmium plated brass binder head screw terminals.

The controller assembly cabinet contents shall be functionally arranged within the cabinet such that they will not hinder the entrance, training and connection of the incoming conductors. Unnecessary overlapping of conductors will not be permitted unless approved by the Engineer.

Wiring within controller cabinets shall be neatly arranged and laced or enclosed in plastic tubing or raceway.

The outgoing traffic control signal circuits shall be of the same polarity as the line side of the power supply. The common return of the signal circuits shall be of the same polarity as the ground or neutral side of the line power supply.

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The grounded side of the line power supply shall be grounded to the controller cabinet in an approved manner.

Field terminals shall be installed a minimum of 5 inches above the bottom of the cabinet and in such a manner that they are easily accessible without removal of any other equipment and oriented for screwdriver operation.

F. Radio Interference Suppressor. Radio interference suppressors shall be installed in each solid-state digital controller and shall provide a minimum attenuation of 50 decibels over a frequency range of 200 kilohertz to 75 megahertz when used in connection with normal installations. The interference suppressor shall be hermetically sealed in a substantial metal case filled with a suitable insulating compound. Terminals shall be long enough to provide space for connecting two No. 8 conductors and shall be so mounted that the terminals cannot be turned in the case. Suppressors shall be designed for 125 percent of the total connected load and shall meet standards of the UL and the Electronic Industrial Association. The minimum size suppressors shall be 25 amperes on 120 volts, 60-hertz, single-wire circuits.

G. Surge Arrestor. Surge arrestors shall be provided in each solid-state digital controller to protect the controller components from lightning and other power fluctuations. The surge arrestors shall meet or exceed the following specifications:

Peak current	20,000 amps (8 x 20 us waveshape)
Occurrences	20 times minimum @ peak current
Clamp voltage	340 volts @ 20KA.
Response time	Voltage never exceeds 340 volts during surge
Series Inductance	200 uH minimum
Continuous Service Unit	10 Amps maximum 120 VAC, 60Hz.
Dimensions (inches)	2.87 W x 5.25 L x 1.75 H
Temperature Range	-40° to 85° C
Weight	1.5 pounds

825.04 CONSTRUCTION METHODS. The vehicle actuated solid-state traffic signal controller shall be installed at the location shown on the Plans in accordance with the manufacturer's requirements and Specifications.

825.05 METHOD OF MEASUREMENT. Traffic vehicle actuated solid state digital traffic signal controller units with auxiliary equipment including cabinet and installation will be measured by the unit, complete in place.

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825.06 BASIS OF PAYMENT. Traffic vehicle actuated solid-state digital traffic signal controller assemblies, measured as provided above, will be paid for at the contract unit price for:

Vehicle Actuated Solid-State Traffic Signal Controller Assembly	Ea.
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which shall be full compensation for furnishing all materials, equipment, labor and incidentals necessary to complete the work as specified.

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826.00 PRE-TIMED SOLID STATE DIGITAL TRAFFIC SIGNAL CONTROLLER

826.01 DESCRIPTION. These specifications describe the design and general requirements for a controller assembly which uses solid-state digital circuitry, integrated or undivided components, in modular type construction in the controller unit.

This controller assembly shall consist of a solid-state, digital pre-timed traffic signal controller that shall be of multiple cycle length, offset and signal sequence design. The unit shall be capable of master-secondary operation. The controller unit shall meet all related terminology of NEMA (National Electrical Manufacturer's Association) Standard Publication of the latest revision for pre-timed controller unit.

The above-defined requirements are MINIMUM requirements, and the intent is to define signal operation and not internal design or method of accomplishment.

826.02 MATERIALS.

A. General. The controller unit shall comply with Part 2, Section 1 and Part 3, Paragraph 3.02 pertaining to DC logic levels of NEMA Standards Publication No. TS 1-1976 and any subsequent revisions of the publication.

Each signal sequence and the state of each implemented signal circuit (on, off or flash) shall be programmed in Read Only Memory. Timing for each movement of each signal sequence shall be programmable in Random Access Memory non-volatile read/write memory or by the use of switches or pins in non-keyboard-entry controllers. No external programming devices shall be used to set timing in the controller.

The controller unit circuit boards shall be modular in design. The modules shall be readily accessible for maintenance and shall plug-in by means of card guides. However, the power supply transformer, capacitors and power-dissipating components are excepted from this requirement. The design shall allow for removal or replacement of a module without unplugging or removing other modules or boards. Similar modules shall be interchangeable between like manufacturer's controller units.

If the controller unit utilizes a face plate and/or face plate PC boards, the displays and switches shall remain operable when the face plate is opened for maintenance. Special tools shall not be required to remove or replace a

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module. The module shall not employ layered construction of PC boards that would prevent reasonable access to the components on the module.

All circuits shall consist entirely of solid-state electronic circuitry. Reed switches will not be permitted.

All printed circuits shall be made from FR-4 or G-10 glass epoxy, or equivalent, and shall have a nominal thickness of at least 1/16 inch with 2 ounces per square foot or more copper track.

All components shall be amply de-rated with regard to heat dissipating capacity and rated voltage so that, with maximum ambient temperature and maximum applied voltage, the controller assembly shall maintain its programmed functions.

When batteries are used, they shall be a rechargeable type. A charging circuit shall be provided to recharge and maintain a charge on the batteries and, a circuit shall be provided to protect any batteries subject to polarity reversal from this occurrence.

The design life of all components, except for the batteries, under 24-hour per day ordinary operating conditions in their circuit operation, shall not be less than 5 years. The battery(ies) shall be capable of withstanding and operating within the temperature and humidity requirements of the controller assembly and shall have a design life of at least 4 years under ordinary operating conditions.

Any RAM memory described above shall be maintained for 30 days in the event of a power failure. This RAM memory shall also be maintained for a minimum of two hours when the circuit board containing this RAM is removed from the main chassis.

B. *Main Frames.* The maximum chassis dimensions of the controller unit shall not exceed 12 inches in height, 17 ½ inches in width, and 12 inches in depth.

All exterior surfaces of the mainframe shall be coated with a suitable protective finish.

The model and serial numbers shall be shown on the mainframe of the controller unit.

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The mainframe shall contain a Slo-Blo fuse for the 120 volts, 60 Hz AC supply to the unit. Also, a standard fuse shall be provided for the 24-volt DC external output from the unit. Fuses shall be of the proper value to protect the circuits involved.

A set of switches, pins, or a keyboard panel shall be provided for the purpose of programming the time for each movement, cycle length, and offset into the controller. Inputs to the unit shall determine which cycle length, offset, and signal sequence is to be in effect at a given time. The user shall be able to monitor and revise data stored memory without affecting the operation of the unit. The ability to manually select any combination of programmed cycle length, offset, or any signal sequence shall be provided. If the ability to do this manual selection is not provided in the controller unit it shall be provided in the cabinet.

A front panel display shall be provided. It shall be a direct reading display which displays, as a minimum, intervals, interval times, cycle lengths, offsets, signal sequence, and synchronization status. Any illuminated LED or LCD display shall have a minimum height of 0.30 inches and shall be visible when shaded from direct sunlight.

A press-to-test switch or continuous self-test shall be provided to test the main battery and indicate condition. It shall isolate the battery from the controller unit and apply a load to the battery simulating a power failure.

Circular, quick-disconnect connector(s) (a maximum of two) shall be provided for electrical connection to external input and output circuits. The minimum inputs and outputs shall be:

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INPUTS	OUTPUTS
AC+	Sync
AC-	Signal Circuits 1-21
°FFSET 1	Interval 1 on (Begin Cycle)
°FFSET 2	(2 Sec. Min. Duration)
°FFSET 3	Chassis Ground (Second
Cycle 2	Connector if Furnished)
Cycle 3	Logic Common Voltage Monitor
Chassis Ground	+ 24 VCD
Signal Sequence 2	
Signal Sequence 3	
Phase 1 Call (If Required)	
Phase 5 Call (If Required)	
Indicator Disable (When Required)	
External, Start	
Internal Advance	
Manual Control Enable	
Stop Timing	
Interconnect Common (When Required)	

C. Cycle Length. Three independent cycle lengths may be provided as shown on plans. Transfer from one cycle length to another shall be programmable by the user to occur at any safe point in the cycle common to all signal sequences.

Cycle lengths shall be adjustable from 30-250 seconds in one second increments.

1. *Offsets.* Three separate offset shall be provided for each cycle length for a total of nine offsets. Each offset shall be programmable from either 0-250 seconds in one second increments or 0-99 in one percent increments.

The programmed offset defines either the number of seconds or percent by which the beginning of the local cycle follows the system sync pulse. A sync of 2 seconds minimum duration shall be imposed upon the offset line in effect.

Offset transfer shall be accomplished by either shortway or maximum dwell transfer procedures.

- a. If the shortway method is used, the local cycle length shall be lengthened or shortened during selectable intervals to enable the controller to gradually assume the new offset without dwell or undue disruption of traffic.

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b. If the dwell method is used, the controller unit shall dwell at the beginning of the local offset point for a programmed maximum time, 0-250 seconds in one second increments or until the end of the programmed offset, whichever occurs first.

2. *Signal Sequences.* There shall be three signal sequences provided as shown herein, and they shall each be able to be used with any of the cycle lengths.

The timing for each signal sequence for each cycle length shall be individually programmable.

3. *Timing.* The minimum timing range for each signal indication shall be programmable as follows:

SIGNAL INDICATION	RANGE	INCREMENTS (Seconds)
Green	0-99	1
Yellow Clear	0-7	0.25
Red Clear	0-3	0.25
Walk	0-30	1
Flashing Don't Walk	0-30	1

or programmable from 0-99 percent in one percent increments.

4. *Signal Circuits.* The controller unit shall provide for a minimum of 21 signal circuits.

The flash rate of any signal circuit programmed to flash shall be 60 times per minute with a 50 percent + 2 percent duty cycle.

5. *Features of Operation.* The controller unit and associated equipment shall be designed to provide the operation and phasing shown herein.

Pedestrian phasing shall consist of steady "Walk", flashing "Don't Walk" (pedestrian clearance interval) and solid "Don't Walk".

6. *Controller Cabinets.* Each pre-timed controller unit and auxiliary equipment shall be enclosed in an approved weatherproof aluminum alloy cabinet of the type regularly supplied by the manufacturer, unless otherwise specified. Size of cabinet shall be such as to provide ample space for housing, the control unit, and all of the associated electrical devices, including the additional expansible equipment for which provisions are made. A hinged door shall be provided permitting complete access to the interior of the cabinet. The door shall be sealed by neoprene gasketing material making the cabinet weatherproof. The door shall be furnished with a Corbin No. 2 lock and two keys. An

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auxiliary police door shall be provided in the main cabinet door with a standard police lock and two keys. The panel behind the auxiliary door shall be furnished with a main power switch, a signal flashing switch, manual-automatic switch and phone type receptacle for manual control. The cabinet shall be equipped with a thermostatically controlled cabinet vent fan with intake and exhaust vent openings. All vent openings shall have a vent covering. Vent covers shall be screen or hardware cloth having square openings no larger than 0.0125 square inch. A panel with punched or drilled holes no larger than 0.025 square inch in area is acceptable provided that adequate cabinet ventilation is maintained.

The fan thermostat shall be mounted near the top of the cabinet and shall be a fixed type that turns on at 150° F and off at approximately 100° F.

The load switch supports shall be so designed and constructed to receive all load switches which may be manufactured to the maximum size requirements permitted under the latest revision NEMA (National Electrical Manufacturer's Association).

7. *Controller Inputs and Outputs.* Each input and output function shall be distinctly identified with no obstructions, at each terminal point in the cabinet, either by number or function terminology. The same identification shall be used consistently on the cabinet wiring diagrams.

Each load switch socket shall be identified by phase number and overlap number as applies. No cabinet equipment may obstruct these identifications.

Each flash transfer base and power relay base shall be properly identified with no possible obstructions.

Each harness within the cabinet shall be distinctly identified on the connector end.

The flasher socket shall be distinctly identified with no possible obstructions.

All other sockets needed within the cabinet to fulfill the minimum requirement of the Plans, or attachments thereof, shall be distinctly identified.

Except where soldered, all wires shall be provided with lugs or other approved terminal fittings for attachment to binding posts. Insulation parts and wire insulation shall be of suitable material and insulated for a minimum of 600 volts.

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The controller equipment and terminals shall be so arranged in the cabinet that they will not upset the entrance, routing and connection of incoming conductors.

The outgoing traffic control signal circuits shall be of the same polarity as the line side of the power source. The common return of the signal circuit shall be of the polarity as the ground side of the power source. The grounded side of the AC power source shall be grounded to the controller cabinet in an approved manner.

8. *Terminal Identification.* All terminals shall be permanently identified in accordance with the cabinet wiring diagram. Where through-panel solder lugs or other suitable connectors are used, both sides of the panel shall have the terminals properly identified. Identification shall be permanently attached as close to the terminal strip as possible and shall not be affixed to any part which is easily removable from the terminal block panel.
9. *Auxiliary Equipment.* Unless otherwise called for on the Plans, two circuit breakers shall be mounted and wired in the cabinet. One 20 ampere breaker shall protect the base light, trouble light, flasher and duplex receptacle. The second breaker (30 ampere) for the back panel shall be so wired to protect the signal load circuits and controller circuits. The breakers shall be of the thermal magnetic or magnetic type rated at 120 volts single pole nonadjustable.

The circuit breaker(s) are to be equipped with solderless connectors and installed on the sidewall or lower right-hand side of the back panel inside the cabinet in such a manner that their rating markings shall be visible and the breaker shall be easily accessible.

The circuit breakers shall be capable of manual operation with the switch marked to indicate whether it is in the open or closed position.

A duplex receptacle of the three wire grounding type shall be mounted and wired in the cabinet and it shall accept a standard two-pronged, non-grounding plug. This receptacle shall be wired on the load side of the 20 ampere breaker as specified.

A switch shall be provided such that when the door of the cabinet is closed it shall automatically turn off all incandescent indicators of the controller unit.

A fluorescent trouble light, with switch, shall be installed in the cabinet. This light shall be activated when the cabinet door is opened and turned off when the cabinet door is closed.

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A radio interference suppressor shall be provided and installed on the load side of the signal circuit breaker and shall be protected by the surge protector specified above. This filter shall be rated at 30 amperes and shall provide a minimum attenuation of 50 decibels over the frequency range of 200 kilohertz to 75 megahertz.

A surge arrestor shall be furnished in each traffic signal controller. The arrestor requirements are as follows:

Peak Current	20,000 amps(8 x 20 us waveshape)
Occurrences	20 times minimum @ peak current
Clamp Voltage	340 volts @ 20KA
Response Time	Voltage never exceeds 340 volts during surge
Series Inductance	200 uH minimum
Continuous Service Current	10 Amps, maximum 120 VAC, 60 Hz
Dimensions (inches)	2.87 (W) x 5.25 (L) x 1.75 (H)
Temperature Range	-40° to +85° C
Weight	1.5 pounds

10. *Test Normal.* A switch shall be provided on the inside of the cabinet door, which when in the on position shall allow the controller unit and logic to operate during flash operation. When this switch is off, flash operation shall remove power from the controller unit and logic.

A circuit shall be provided and wired to the conflict monitor output and it shall flash the signals when a conflict exists.

11. *Stop Time.* A flash transfer control switch shall be provided in the police panel, which when activated shall place the signals into the flash operation called for on the attached signal sequence diagram.

The cabinet back panel shall either have all of the wiring on its front, or the wiring shall be readily accessible by means of a hinge enabling the back panel to swing down or sideways. Readily accessible shall mean that it shall be possible to gain full access to inspect or modify the wiring in less than 2 minutes by the use of simple tools. If the wiring is on the back of the back panel, the panel and wiring shall be designed so as to prevent the wiring from being pinched or chafed when the panel is placed in its normal operating position after a change in wiring is made. If a side panel with through panel solder lugs or other suitable connectors is provided, both sides shall also be readily accessible as described above.

Transfer relays shall be plug-in type manufactured by Mid-Tex (Part No. 136-62T3A1) or AEMCO (Part No. 136-4992) or equivalent.

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12. *Conflict Monitor.* The conflict monitor shall meet the NEMA (National Electrical Manufacturer's Association) Publication No. TS 1, Part 6, of the latest revision, for 3, 6 and 12-channel types.

In addition to the above requirements, a light display shall be provided to indicate continuously when a channel is active due to green, yellow or walk inputs. It shall also continue to display the channels which were active at the time of a conflict, until the conflict monitor is manually reset.

If the conflict was caused by a loss of red, the display array shall indicate loss of red.

If the conflict was caused by the voltage monitor, the display array shall indicate a voltage error.

The conflict monitor shall be preprogrammed for the operation called for on the Plans.

13. *Solid State Load Switch.* The solid state load switches shall meet the requirements set forth in Part 5 of the NEMA Specification of the latest revision and shall be "Triple-Signal Load Switch" type.

The load switches shall have no moving parts. Load switches using reed relays will not be permitted.

An indicator light for each circuit shall be provided in each load switch. The indicator light shall be on when a true input to the load switch is present.

14. *Two-Circuit, Solid-State Flasher.* The flasher shall meet the electrical and physical characteristics described in Part 8 of the NEMA Standards Publication latest revision and shall be "Triple-Signal Load Switch" type.

The-two circuit flasher shall be of solid-state design and contain no electro-mechanical devices.

The solid-state flasher shall conform to Section 827.

826.04 CONSTRUCTION METHODS. The pre-timed, solid-state, digital traffic signal controller shall be installed at the location shown on the Plans in accordance with manufacturer's requirements and specifications.

826.05 METHOD OF MEASUREMENT. The pre-timed, solid-state, digital traffic signal controller unit with auxiliary equipment including cabinet and installation will be measured by the unit, complete in place.

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826.06 BASIS OF PAYMENT. The pre-timed, solid-state digital traffic signal controller assembly, measured as provided above, will be paid for at the contract price for:

Pre-timed, Solid-State, Digital Traffic Signal Controller Assembly	Ea.
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which payment shall be full compensation for furnishing materials, equipment, labor and all incidentals necessary to complete the work as specified.

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827.00 SOLID-STATE FLASHING CONTROLLER

827.01 DESCRIPTION. This work shall consist of furnishing materials and installing a solid-state flashing controller in accordance with these Specifications.

827.02 MATERIALS. The flasher shall be a solid-state electrical device with no contact points or moving parts, producing between 50 and 60 flashes per minute at 50 percent ON and 50 percent OFF periods. The flashing mechanism shall be mounted on a plug-in base with a plug-in mounting. The flasher shall utilize zero-point switching, with turn-on at the zero voltage point + 5 degrees, and turn-off at the zero current point + 5 degrees, of the power line sinusoid.

The flasher shall provide two output circuits to permit alternate flashing of signal heads and shall be capable of carrying a minimum of ten amperes per circuit at 60-cycle, single-phase, 120 volts alternating current + 15 percent voltage in ambient temperature between -30° to 160° F.

The flasher unit and associated equipment shall be enclosed in an approved weatherproof or aluminum alloy cabinet of the type regularly supplied by the manufacturer. The size of the cabinet shall provide ample space for housing the flashing unit and all of the associated electrical devices.

The cabinet shall be in accordance with Subsection 825.02.

A hinged door shall be provided permitting complete access to the interior of the cabinet. The door shall be sealed by neoprene gasketing material making the cabinet weatherproof. The door shall be furnished with a standard police lock and two keys.

Terminals shall be identified, accessible without removal of equipment contained in the cabinet, and connected to terminal boards.

A radio interference suppressor meeting the requirements of Section 825 shall be supplied.

The circuit breaker shall be in conformance with requirements of the NEC.

827.04 CONSTRUCTION METHODS. The solid-state, flashing controller shall be mounted on the signal pole and wired for operation.

827.05 METHOD OF MEASUREMENT. The solid-state, flashing controller and associated equipment, including cabinet, will be measured by the unit, complete in place, not including post and footings.

827.06 BASIS OF PAYMENT. The accepted solid-state flasher controller, measured as provided above, will be paid for at the contract unit price for:

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Solid-State Flasher Controller

Ea.

which shall be full compensation for furnishing all materials, equipment, labor and incidentals necessary to complete the work as specified.

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828.00 SOLID-STATE, DIGITAL INDUCTIVE VEHICLE LOOP DETECTOR AND LOOPS

828.01 DESCRIPTION. This work shall consist of furnishing materials and installing a solid-state, digital inductive vehicle loop detector and loops in accordance with these Specifications, the latest NEMA Specifications, and as shown on the Plans.

828.02 MATERIALS.

A. *Detector Loop.* The detector loop wire that is embedded in the pavement for the detector loop shall be a number 14 AWG stranded copper cross-linked polyethylene insulated wire (Types XHHW, HAZ, XLP, XLPE, THHN and RHW), conforming to National Electrical Code and meet the requirements of Subsection 738.01 C. of Section 700.

B. *Detector Unit.* The detector unit shall be self-contained, self-tuning solid-state digital and shall compensate automatically for variations in temperature and environmental conditions.

1. *Mechanical Requirements.* The complete detector unit, including power supply, shall be completely enclosed in a sheet metal housing with a protective paint finish. The case shall be so designed to provide convenient access to the entire interior assembly to permit easy testing and servicing of parts. Each detector unit shall be supplied with a connecting cable. Electrical connection from the detector to the incoming and outgoing circuits shall be made by inserting a multi-terminal plug into the plug receptacle located on the face panel of the detector. The detector shall be replaceable with a similar unit without the necessity of disconnecting and reconnecting the individual wires leading therefrom.

2. *Output Delay and Extend.* The loop detector unit shall, when specified on the Plans, be supplied with programmable delay and extend output features.

2.1 *Delay Output.* A variable delay circuit shall be furnished to provide a delayed output. This circuit shall be variable from zero to at least 20 seconds in one-second increments. Detection of a vehicle shall be delayed for the amount of time selected, therefore providing no detector output until a vehicle has been present in the loop for this length of time. This timing shall reset each time the loop is vacated. However, the delay circuit shall be disabled immediately when 120 VAC is present on pin J of the MS 3106A-18 1P connector for this channel.

2.2 *Extend Output.* A variable extend circuit shall be furnished to provide a carryover output. This circuit shall be variable from zero to

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at least 15 seconds in 0.25 second increments. Detector actuation shall be extended after the vehicle leaves the loop. The timing circuit shall reset after the extension has expired. However, the extend circuit shall not be disabled when 120 VAC is present at Pin J of the connector described again.

The timing shall be digital and all programming settings shall be accomplished by pins, thumbwheels or dip switches. The delay and extend features described herein shall not be required to function simultaneously unless otherwise specified on the Plans.

All programming (extend, delay, retention of presence, etc.) shall be external and located on the face of the unit.

3. *Operating Requirements.* The detector shall be designed so that environmental metal objects in the vicinity of the loop shall not affect its operation. The circuit design shall permit the lead-in cable described in Section 834 to be placed in a common conduit with signal and interconnect cable without any interference to the operation of the detector.

The detector shall be designed to operate satisfactorily in temperatures ranging from -30° to 160° F. The detector shall be designed to operate satisfactorily on line voltage of single-phase, 120 volts, 60-cycle alternating current. This voltage may vary +15 percent without any noticeable effect of the operation or life of the detector equipment. The detector unit shall have a tuning range of loop inductance from 40 to 700 micro-henries. The detector shall be capable of detecting vehicles traveling at speeds ranging from 0 to 100 mph and shall detect only those vehicles that pass over any portion of the loop. Should power fail momentarily, the detector, when power is restored, shall return to its condition at the time of the power failure. If in the rest condition, it shall return to the rest condition or if in detect condition it shall return to the detect condition.

4. *Electrical Requirements.* Circuitry of the detector shall be all solid-state. The printed circuit board shall be as described in Section 825. Facilities for adjusting the detector shall be an integral part of the detector on the front panel. Loop tuning shall be a simplified procedure which may be performed without traffic activity and without the need of test apparatus. There shall be two operating modes, pulse and presence. The operating mode shall be independently selected for each detector by means of switches located on the front of the detector unit. Each detector unit shall be furnished with a surge protector to protect the detector unit from lightning or other like disturbance. The detector shall be provided with a multi-conductor color-coded harness and connector of the MS type. Each detector unit shall be provided with a fuse replaceable without tools,

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located on the front panel. Each detector unit shall be permanently grounded internally. Visual indication of vehicle detection shall be provided by an indicator light located on the front panel.

828.04 CONSTRUCTION METHODS. The detection loop of the system shall be properly installed in order that it will perform reliably over a long period of time. The loop detection system shall be located as shown on the Plans. The exact location shall be marked on the roadway with chalk string, spray paint or some suitable marking device that can withstand weather and traffic until such time as the locations have been approved by the Engineer. The induction loop slot, including corner cuts, shall be cut to the exact width and depth as shown on the Plans. The slot shall be cleaned and dried with compressed air to remove all water and debris. All loop wires in any given location shall be wound in the same direction. All loop wire shall be one continuous length to the pull box or the junction conduit where it shall be connected to the lead-in cable. A blunt wood instrument shall be used for placing the wire into the slot so that the insulation is not damaged in any way. All connections that are made from loop wire to the lead-in cable shall be made only in the junction conduit or the pull box. The connection shall be soldered with a 60/40 alloy, rosin core solder. Care shall be taken while soldering not to damage the insulation of the wire and cable. When the connection has been completed, a resin-filled connector sealing pack shall be placed over it. If no lead-in cable is required, then the loop wire shall be connected directly to the terminal block that is located in the base of the traffic signal pole. After the loop wire has been carefully placed in the slot and circuitry checked by the contractor, the slot shall be sealed with a sealer as shown on the Plans.

828.05 METHOD OF MEASUREMENT. The solid-state digital inductive vehicle loop detector installed will be measured by the unit, complete in place, wired and connected to the controller. The loop detector wire will be measured by the linear foot installed and connected to the loop detector.

828.06 BASIS OF PAYMENT. The accepted solid-state digital inductive vehicle loop detector and loop detector wire, measured as provided above, will be paid for at the contract unit price for:

- | | |
|--|----------|
| A. Solid-State Digital Inductive Vehicle Loop Detector | Ea. |
| B. Loop Detector Wire | Lin. Ft. |

which shall be full compensation for furnishing materials, labor, equipment and incidentals necessary to complete the work as specified.

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830.00 PEDESTRIAN PUSH BUTTON

830.01 DESCRIPTION. The work shall consist of furnishing materials and installing pedestrian push buttons and signs on traffic signal installations in accordance with these Specifications and as shown on the Plans.

830.02 MATERIALS. The pedestrian push button switch shall be a phenolic enclosed precision snap acting single pole, single-throw unit with screw type terminals rated at 5 amperes at 125 volts AC.

Materials for pedestrian information signs shall be as shown on the Plans.

830.03 CONSTRUCTION METHODS. The pedestrian push button shall be constructed to be tamper proof. It shall be so designed in construction that it will be virtually impossible to receive any electrical shock under any weather condition.

The pedestrian push button and sign shall be attached to a traffic signal pole or steel pipe as shown on the Plans. The housing shall be shaped to fit the curvature of the pole or pipe and secured to provide a rigid installation.

830.04 METHOD OF MEASUREMENT. The pedestrian push button will be measured by the unit complete in place, connected, including signs and all hardware.

830.05 BASIS OF PAYMENT. The accepted pedestrian push button, measured as provided above, will be paid for at the contract unit price for:

Pedestrian Push Button	Ea.
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which shall be full compensation for furnishing materials, labor, equipment and incidentals necessary to complete the work as specified.

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831.00 TRAFFIC SIGNAL HEADS

831.01 DESCRIPTION. This item shall consist of providing and installing traffic signal heads and lamps on various types of supports at locations shown on the Plans and in conformance with these Specifications and the Institute of Traffic Engineers Standard Specifications.

831.02 MATERIALS. The traffic signal head or pedestrian head and all component parts can be either polycarbonate or die cast aluminum and shall conform to the ITE Standard for Adjustable Face Vehicular Traffic Control Signal Heads. All pedestrian signal heads shall meet the requirements of the ITE Standard Adjustable Face Pedestrian Signal Head Standard.

Traffic signal lamps furnished shall conform to the ITE Standard for Traffic Signal Lamp.

A minimum of 60 watt, 120 volt, clear, traffic signal lamps of 8000 hour minimum rated life shall be furnished with 8-inch heads and 9-inch pedestrian heads. A 150 watt, 120 volt, clear, traffic signal lamp of 6000 hour minimum rated life shall be furnished with both 12-inch traffic and pedestrian signal heads. All reflectors shall be specular alzak aluminum.

All die cast aluminum surfaces of the door, visors, and signal housing inside and outside shall be painted before assembly with three coats as follows:

First Coat – Primer: Shall be Oxide Baking Primer and shall meet or exceed the performance specifications of Federal Specifications TT-P-636.

Second Coat – Grey Enamel: Shall be medium Grey Alkyd Urea Exterior Baking Enamel and shall comply with Federal Specifications TT-E-489.

Third Coat – Yellow Enamel: Shall be Highway Yellow, best quality, synthetic resin enamel. The third coat on the inside and outside of the visors and the face of the signal doors shall be an Alkyd Urea Exterior Synthetic Baking Enamel, with minimum gloss reflectance meeting the performance requirements of TT-E-489, Enamel Heat Resisting Glycerol Phthalate, Type 4, Instrument Black.

831.04 CONSTRUCTION METHODS. Each signal head shall be a weather-tight assembly of one or more signal sections of the adjustable, incandescent type, together with all brackets and fittings necessary for proper mounting on the type of signal support designated on the Plans. Each signal head shall consist of one or more signal sections rigidly and securely fastened together, capable of being positively positioned to control the movement of one direction of traffic. Each signal section shall be a self-contained assembly consisting of an optical unit with housing, housing door, and visor.

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831.05 METHOD OF MEASUREMENT. The traffic signal heads and lamps will be measured by the unit, complete in place including wiring and all hardware.

831.06 BASIS OF PAYMENT. The accepted traffic signal heads and lamps, measured as provided above, will be paid for at the contract unit price for:

Traffic Signal Heads

Ea.

which shall be full compensation for furnishing materials, labor, equipment and incidentals necessary to complete the work as specified.

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832.00 OPTICALLY PROGRAMMED ADJUSTABLE TRAFFIC SIGNAL HEADS

832.01 DESCRIPTION. This work shall consist of providing and installing optically programmed adjustable traffic signal heads and lamps on various types of supports at locations shown on the Plans in conformance with these Specifications.

832.02 MATERIALS. The optically programmed adjustable traffic signal head shall permit the visibility zone of the indication to be determined optically and require no hoods or louvers. The projected indication(s) may be selectively visible or veiled anywhere within 15° of the optical axis and shall emanate from a single section. No indication shall result from external illumination nor shall one light unit illuminate a second.

A. *Optical System.*

1. The lamp shall be nominal 75 watt, 120 volt AC, three prong, sealed beam having an integral reflector with stippled cover and an average rated life of at least 6,000 hours.
2. The lamp collar including specular inner surface shall couple the lamp to the diffusing element.
3. The diffusing element may 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 1200 feet distance and permit an effective veiling mask to be variously applied as determined by the desired visibility zone. The optical limiter shall be composed of heat-resistant glass.
4. The objective lens shall be a high-resolution planar incremental lens hermetically sealed within a flat laminant of weather-resistant acrylic or approved equal. The lens shall be symmetrical in outline and may be rotated to any 90° orientation about the axis without displacing the primary image. The optical system shall accommodate projection from a single section of diverse selected indicia to separate portions of the roadway such that only one indication will be simultaneously apparent to any viewer.
5. The projected indication shall conform to ITE chromaticity standards.

B. *Electrical.* The lamp fixture shall comprise a separately accessible housing and integral lamp support, indexed ceramic socket and self-aligning, quick-release lamp retainer. Electrical connection between case and lamp housing shall be accomplished with an interlock assembly which disconnects lamp holder when opened. Each signal section shall include a covered terminal block for clip or screw attachment of lead wires. Concealed copper #18 AWG,

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stranded and coded wires shall interconnect all sections to permit field connection within any section.

C. Photo Controls. Each signal section shall include integral means for regulating its intensity between limits as a function of individual background illumination. Lamp intensity shall not be less than 97 percent of uncontrolled intensity at 1000 ft-c, and shall reduce to 15 percent + 2 percent of maximum at less than one ft-c. Response shall be proportional and essentially instantaneous to any detectable increase of illumination from darkness to 1000 ft-c, and damped for any decrease from 1000 ft-c.

The intensity controller shall comprise an integrated, directional light-sensing and regulating device interposed between lamp and line wires. It shall be compatible with 60-hertz input and responsive within the range 105 to 135 volts. Output may be phase-controlled, but the device shall provide a nominal terminal impedance of 1200 ohms open circuit and a corresponding holding current.

832.04 CONSTRUCTION METHODS. Die cast aluminum parts shall conform to ITE alloy and tensile requirements and have a chromate preparatory treatment. The exterior of the signal case, lamp housing and mounting flanges shall be finished with a high-quality prime baked enamel and finish paint. The lens holder and interior of the case shall be optical flat black. Signal case and lens holder shall be pre-drilled for backplates and visors. Hinges and latch pins shall be stainless steel. All access openings shall be sealed with weather-resistant rubber gaskets. The signal shall mount to standard 1½ inch fittings as a single section, as 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 0-20 degrees below the horizontal while maintaining a common vertical axis through couplers and mounting. Mounting attachment shall permit external adjustment about the mounting axis in 5 degree increments. The signal shall be mountable and capable of being serviced with ordinary tools. Attachments such as visors, backplates or adapters shall readily fasten to existing mounting surfaces without affecting water and light integrity of the signal. The signal shall be installed, directed and veiled in accordance with manufacturer's instructions. Each section of the signal shall be masked with prescribed materials in an acceptable and workmanlike manner.

832.05 METHOD OF MEASUREMENT. Optically programmed adjustable traffic signal heads will be measured by the unit complete in place including masking, wiring and all hardware.

832.06 BASIS OF PAYMENT. Accepted optically programmed adjustable traffic signal heads, measured as provided above, will be paid for at the contract unit price for:

Optically Programmed Adjustable Traffic Signal Heads	Ea.
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which shall be full compensation for furnishing materials, labor, equipment and incidentals necessary to complete the work as specified.

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833.00 TRAFFIC SIGNAL BACK PLATES

833.01 DESCRIPTION. This work shall consist of furnishing and installing backplates to traffic signal heads in accordance with these Specifications and as shown on the Plans.

833.02 MATERIALS. Backplates shall meet the requirement of Section 740.

833.03 CONSTRUCTION METHODS. The backplates shall consist of one-piece construction. The back plates shall be secured to the traffic signal heads with non-corrosive machine screws and lock nuts as shown on standard drawings.

833.04 METHOD OF MEASUREMENT. Backplates will be measured by the unit complete in place.

833.05 BASIS OF PAYMENT. Backplates, measured as provided above, will be paid for at the contract unit price for:

Backplates	Ea.
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which shall be full compensation for furnishing materials, labor, equipment and incidentals necessary to complete the work as specified.

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834.00 ELECTRICAL CONDUCTORS TRAFFIC SIGNAL

834.01 DESCRIPTION. This item consists of furnishing materials and installing electrical conductors for traffic signal systems as shown on the Plans.

834.02 MATERIALS. The electrical conductors shall meet the requirements specified in the following Subsections of Section 700. Traffic Signal Wire and Cables:

Traffic signal Electrical Cable	738.01 A.
Shielded Loop Detector Lead-In Cable	738.01 B.

834.04 CONSTRUCTION METHODS.

A. Traffic Signal Electrical Cable. Traffic signal electrical cable shall be installed from the heads on each traffic signal pole to the traffic signal controller. The electrical cable from the traffic signal pole to the controller shall be in conduit. The electrical cable to be furnished shall have a sufficient number of conductors and at least one spare conductor as shown on the Plans.

B. Shielded Loop Detector Lead-In Cables. The shielded loop detector lead-in cables shall be placed in conduit from each loop detector pull box location to the traffic signal controllers. At each of the loop detector pull box locations, the loop wire or the sensing element lead shall be spliced to the loop detector lead-in cable as shown on the Plans.

834.05 METHOD OF MEASUREMENT. The electrical conductors will be measured by the linear foot for each of the various types specified, installed, and shall include all connectors, splices and incidentals necessary to complete the traffic signal system as provided on the Plans.

834.06 BASIS OF PAYMENT. The accepted electrical conductors, measured as provided above, will be paid for at the contract unit price for:

A. Traffic Signal Electrical Cable	Lin. Ft.
B. Shielded Loop Detector Lead-In Cable	Lin. Ft.

which shall be full compensation for furnishing materials, labor, equipment and incidentals necessary to complete the work as specified.

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835.00 SOLID-STATE TIME CLOCK

835.01 DESCRIPTION. This work shall consist of furnishing materials and installing a solid-state time clock in accordance with these Specifications.

Time of day, day of week, date, year and the operation of the relay output shall be easily settable from the integral keyboard. The functions of the keys shall be clearly marked on the keypad. All data required to properly set and program the unit and review the stored program shall be clearly displayed without the use of the auxiliary devices.

Changeover from standard time to daylight savings time or vice versa shall be accomplished automatically. This program shall be valid once the unit has been programmed with the time of day, month, date and year in which it is operating. From this entry, at the appropriate time each year the change will be made automatically for an indefinite time into the future according to current U. S. law. This feature shall be defeatable by a simple hardware change.

When the user is programming the unit, the display shall provide for verification of each piece of data prior to its being entered. Provisions shall be made for correcting any incorrect data prior to entering it. It shall be possible to alter any individual program step without disturbing any other step in the program.

When an instruction is given to turn the output on or off, that instruction time shall be settable to one minute, and the change shall take place at the zero second of that minute.

The time switch shall be capable of initiating a minimum of six program steps. A program step is defined as the time of day and the day or days of the week at which the output shall be turned on or off.

A set of clear operating instructions shall be furnished with each time switch.

The time switch shall be capable of executing five separate skip plans programmable at least one year in advance.

Programming for the skip plans shall be accomplished through the integral keyboard. Each plan shall be programmed by entering the beginning date (month/day/year) and the ending date for which the output of the time switch will not be activated. The time switch shall be capable of skipping as short a duration as one day or as long as six months. It shall be possible to begin a skip plan in one calendar year and end that same plan in the next consecutive year.

It shall not be necessary to enter the skip plan program in chronological order.

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A means shall be provided to review the skip plan program without affecting the normal operation of the time switch. The display shall include the skip plan number, the beginning date and the ending date.

In addition to the skip plan as described above, the time switch shall also be capable of providing a one-day skip. The programming of this one-day skip may be entered at any time during the six days prior to the day that is to be skipped. After the execution of the one-day skip, the time switch will automatically reset and resume normal operation.

A means shall be provided to maintain timekeeping and the program when the line power source (115 VAC) is temporarily interrupted. This backup system shall maintain timekeeping and all programmed steps intact for not less than 48 hours at 25° C when fully charged and shall go on-line automatically upon failure of the line power. Upon resumption of the line power, the unit shall automatically resume normal operation and begin recharging the backup system. The charging system shall be capacitive. Batteries will not be accepted.

Should the program of the time switch be erased during an AC power outage, the unit shall display an indication of the program loss. The display shall be a discrete LED indicator and shall be resettable from the integral keyboard.

When the time switch is operating on the backup system, the displays shall be blanked and the output disabled to conserve backup power.

Integral with the time switch shall be a clear display of the time of day, day of week, date and the condition of the output relay. If time is kept on a 12-hour format, provisions shall be made to display AM/PM. The unit shall have the ability to switch to an alternate display of time that includes seconds. A single keystroke shall be all that is necessary to switch to this display or to return to the normal display.

A means shall be provided to review the program on the clock memory and such means shall be integral with the input. Such program review shall not affect the current operation of the time switch.

835.02 MATERIALS. This specification sets forth the minimum acceptable design requirements for a single-circuit, solid-state time clock. It is intended for use in traffic control systems and shall be of all solid-state construction except for the relay output. All components shall be made available to the purchaser for servicing for five years after expiration of the manufacturer's warranty or shall be so identified that they may be purchased from industrial electronics suppliers.

The time switch backpanel shall be equipped with a means for mounting to a suitable backplate. Mounting holes that provide clearance for at least a No. 10 screw will be acceptable.

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The time switch shall not exceed 4 inches width x 7-3/8 inches height x 3-1/8 inches depth. A cover shall be provided to protect the time switch from dust. The cover shall fasten securely to the unit and must be easily removable for access to the field wiring terminals. The cover need not be rain tight since the time switch will be installed in an existing aluminum cabinet.

Interface to the power line and to the controlled device shall be provided by means of a terminal block capable of terminating wire sizes ranging from #20 to #12 AWG.

The time switch shall operate on a nominal 115 VAC, 60-hertz power source and shall operate satisfactorily between 95 and 135 VAC and from -30° to 75° C.

Timing shall be synchronous with the power line when such power is available. When commercial power is lost, the timing shall be maintained by a backup power source. Timing accuracy during such backup operation shall be +3 seconds per 24-hour period throughout its full temperature range.

No time shall be gained or lost during changeover from 115 VAC to the backup system and back to 115 A.C. voltage.

All programming shall be accomplished via a keyboard which is an integral part of the unit.

The time of day shall be accurately settable to one second.

835.04 CONSTRUCTION METHODS. The solid-state time clock shall be mounted in a controller cabinet and wired for operation.

835.05 METHOD OF MEASUREMENT. The solid-state time clock will be measured by the unit complete in place.

835.06 BASIS OF PAYMENT. The accepted solid-state time clock, measured as provided above, will be paid for at the contract unit price for:

Solid-State Time Clock	Ea.
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which shall be full compensation for furnishing materials, labor, equipment and incidentals necessary to complete the work as specified.

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850.00 SIGNS

850.01 DESCRIPTION. This work shall consist of furnishing and erecting, complete in place, signs in accordance with these Specifications and in reasonably close conformity with the dimensions and lines shown on the Plans or established by the Engineer. Included are signs of sheet aluminum and extruded aluminum panels, all with a reflective or non-reflective sheeting background and with steel or aluminum sign bracket arms, bolts and fittings.

850.02 MATERIALS. Materials shall meet the requirements of Section 719.

850.03 CONSTRUCTION METHODS.

A. *Cleaning.* Sheet aluminum and extruded aluminum panel signs shall be thoroughly cleaned to remove grease, oil and other contaminants prior to the application of reflective and non-reflective sheeting to insure proper bond of the sheeting adhesive.

B. *Application of Reflective of Non-reflective Sheeting.* Sheeting shall be applied to properly treated base panels with mechanical equipment in a manner as specified below. Class 2 adhesive-coated sheeting shall be pre-perforated.

1. *Vacuum Application.* Reflective or non-reflective sheeting shall be applied to all sheet sign faces by an approved vacuum applicator. The pre-coated adhesive on the back of the sheeting shall be activated by a minimum temperature of 185° F and the sheeting shall be evenly attached to the sign face by the diaphragm of the vacuum applicator which applies continuous even pressure and evacuates, with a minimum vacuum pressure of 25 inches of mercury, all air between the sheeting and the sign face to insure that there are no air pockets or bubbles. This operation shall be in accordance with the recommendations of the manufacturer of the reflective sheeting. After aging for 48 hours at 75° F, the adhesive shall form a bond equal to or greater than the strength of the reflective sheeting.

2. *Continuous Roll Application.* The sheeting with Class 1 adhesive coating shall be applied in a continuous operation over the entire surface of the sign and shall result in a surface free of air pockets or bubbles. The reflective sheeting for extruded panel signs shall extend approximately ¼ inch over each side of the panel and shall be adhered to each side. The sheeting on extruded panels shall not have more than one splice per panel.

3. *Color Match.* Sign faces comprising two or more pieces or panels of reflective sheeting shall be carefully matched for color at the time of sign fabrication to provide uniform appearance and brilliance, both day and

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night. Non-uniform shading and an undesirable contrast between adjacent widths of applied sheeting will not be acceptable.

- 4. Splices.** At splices, Class 1 adhesive-coated sheeting shall be overlapped not less than 3/16 inch. Class 2 adhesive-coated sheeting shall be butt-spliced, gap not to exceed 1/64 inch. Only butt splices shall be used on any sign face that is screen processed with transparent color.

Maximum allowable splices of reflective sheeting on sheet metal signs:

24-inch height sign and under – no splices

36-inch height sign and larger – one horizontal or one vertical splice

- C. Finishing Signs.** Following the application of the reflective sheeting background on sheet metal signs, the messages and border shall be applied by the silk screen process, or when specified by use of cutout legend.

All sign face splices and edges shall be sealed with materials supplied and in a manner specified by the sheeting manufacturer.

Demountable cutout legend, symbols and border shall be attached to the extruded panels with approved fasteners.

The finished signs shall show careful workmanship and have a smooth and uniform light surface. All letters and number shall be clear and sharp.

Sheet signs shall not be permitted to become wet in shipment or storage.

- D. Location and Positioning of Signs.** Signs shall be erected so the sign face is vertical and at a horizontal angle away from the direction of travel as shown on the Plans. Care shall be exercised in the erection of all signs to eliminate or minimize specular reflection.

After installation of the signs is completed, they shall be further inspected at night by the Engineer. If specular reflection is apparent on any sign, its positioning shall be adjusted by the Contractor at his expense to eliminate or minimize this condition.

Lower edge of extruded panel signs on over head trusses shall be aligned along the centerline of the lower horizontal chord member.

850.04 METHOD OF MEASUREMENT. Signs will be measured by the square foot of area of the vertical front face with no deduction for rounding off sign corners.

850.05 BASIS OF PAYMENT. Accepted signs, measured as provided above, will be paid for at the contract unit price for:

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- | | |
|----------------------------------|---------|
| A. Sheet Aluminum Signs | Sq. Ft. |
| B. Extruded aluminum Panel Signs | Sq. Ft. |
| C. Mast Arm Mounted Signs | Sq. Ft. |

which shall be full compensation for furnishing all materials, labor, equipment and incidentals necessary to complete the work as specified.

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851.00 GALVANIZED STEEL SIGN POSTS

851.01 DESCRIPTION. This work shall consist of furnishing materials and constructing galvanized steel sign posts in footings in accordance with these Specifications and in reasonably close conformity with the lines, dimensions, and locations shown on the Plans or established by the Engineer.

851.02 MATERIALS. Materials shall meet the requirements of section 721.

851.04 CONSTRUCTION METHODS. Should it be necessary to field cut a steel post, the cut end shall be placed in the concrete foundation. Any parts of steel posts from which galvanizing has been knocked or chipped off down to bare metal in transit, erection, or field alteration, shall be re-galvanized, metalized or painted with an approved zinc dust-oxide paint.

851.05 METHOD OF MEASUREMENT. Sign posts will be measured by the linear foot of the various sizes of galvanized steel posts erected in place as shown on the Plans or as directed by the Engineer.

On sign posts which require breakaway capabilities the breakaway design elements are considered a part of the sign post and are not measured separately.

Unless otherwise provided, footings will be measured and paid for in accordance with Section 804 and as shown on the Plans.

851.06 BASIS OF PAYMENT. Accepted sign post, measured as provided above, will be paid for at the contract unit price for:

- | | |
|--|----------|
| A. Galvanized Steel Wide Flange Beam Posts | Lin. Ft. |
| B. Galvanized Steel Pipe Posts | Lin. Ft. |

which shall be full compensation for furnishing all materials, equipment, labor and incidentals necessary to complete the work as specified.

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853.00 DELINEATORS

853.01 DESCRIPTION. This work shall consist of furnishing and installing delineators in accordance with these Specifications and in reasonably close conformity with the lines, dimensions and grades shown on the Plans or established by the Engineer.

853.02 MATERIALS. Materials shall meet the requirements of section 710.

853.04 CONSTRUCTION METHODS. Posts shall be installed so that the delineator units will be at the elevations specified on the Plans or established by the Engineer, and they shall be reasonably true to line and grade and plumb.

The posts may be either driven or set. If driven either by hand or mechanical devices, they shall be plumb and firm in the ground, spaced as specified, and driven to the required lines and grades. A suitable driving cap shall be used when posts are driven.

After driving, the top of the posts shall have substantially the same cross-sectional dimensions as the body of the post. Battered heads will not be permitted. Posts bent or otherwise damaged to the extent that they are unfit for use in the finished work shall be removed from the site and replaced by the Contractor at his own expense.

When posts are set, the post holes shall be dug to the correct depth and spaced as shown on the Plans. Post holes shall be backfilled with approved material placed in layers, not more than 6 inches in depth and each layer thoroughly compacted, care being taken to preserve the alignment of the posts. The post must be set to its final position before attaching the delineators.

All bolts and fasteners shall be of the type, length, diameter and material as called for on the Plans, or approved equal.

At bridges, the delineator post shall be fastened to the bridge handrail posts or parapet wall by utilizing brackets and fasteners for the various types as shown on the Plans or approved equal.

853.05 METHOD OF MEASUREMENT. Delineators will be measured by each delineator assembly, including galvanized steel posts. Each type of delineator will be measured separately.

Delineators shall be divided into types and coded for measurement and payment as follows:

- Type 1 – Monodirectional
 - Code 1 – One single reflector
 - Code 2 – Two reflectors placed vertically

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Code 3 – Three reflectors placed vertically

Type 2 – Bidirectional

Code 1 – Two single reflectors mounted back to back

Code 2 – Four reflectors with two on each side of the post, mounted back to back

Code 3 – Six reflectors with three on each side of the post, mounted back to back

The color of the reflectors will be as specified on the Plans or as established by the Engineer.

853.06 BASIS OF PAYMENT. Accepted delineators, measured as provided above, will be paid for at the contract unit price for:

- | | |
|---------------------------------|-----|
| A. Delineators – Type 1, Code 1 | Ea. |
| B. Delineators – Type 1, Code 2 | Ea. |
| C. Delineators – type 1, Code 3 | Ea. |
| D. Delineators – Type 2, Code 1 | Ea. |
| E. Delineators – Type 2, Code 2 | Ea. |
| F. Delineators – Type 2, Code 3 | Ea. |

which shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

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854.00 TRAFFIC STRIPE (PAINT)

854.01 Description. This work shall consist of furnishing materials and placing a white or yellow paint stripe with glass beads applied by the drop-on method in accordance with these Specifications and in reasonably close conformity with the locations, lines and dimensions shown on the Plans or established by the Engineer.

854.02 MATERIALS. Materials shall meet the requirements of Section 711.

854.03 EQUIPMENT. The paint machine shall be capable of applying an even clean-cut line without excessive drifting of paint. The cutoff mechanism on the paint machine shall be capable of making a clean cut end section without dripping or stringing fine lines of paint.

The bead dispenser shall be equipped with an automatic cutoff control synchronized with the cutoff of the striping material.

854.04 CONSTRUCTION METHODS. In order to insure maximum adhesion, the Contractor shall clean all dirt, glaze and grease, road film, and all other foreign materials from the pavement area to be striped.

The material shall be applied to the pavement at a wet film thickness of approximately 0.015 inch.

The beads shall be distributed evenly over the wet paint at a reasonably accurate rate of 6 pounds per gallon of paint, unless a different rate is specified by the Engineer. Beads applied to the surface of the completed stripe shall be applied by an automatic bead dispenser attached to the striping machine in such a manner that the beads are dispensed immediately upon the completed line.

The completed line shall be a uniform cross-section. The paint traffic stripe shall not be applied when there is moisture on the pavement that would cause a poor bond between the paint and the pavement.

Application shall not be permitted when atmospheric temperature is below 40° F and falling.

854.05 METHOD OF MEASUREMENT. Traffic stripe (paint) will be measured by the linear foot of 4-inch wide traffic stripe placed or the equivalent 4-inch stripe necessary when a narrower or wider stripe is specified on the Plans.

854.06 BASIS OF PAYMENT. Accepted traffic stripe (paint), measured as provided above, will be paid for at the contract unit price for:

Traffic Stripe (Paint)	Lin. Ft.
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which shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

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855.00 TRAFFIC STRIPE (PLASTIC)

855.01 DESCRIPTION. This work shall consist of furnishing materials and placing thermoplastic compound or pre-formed plastic tape markings on the roadway in accordance with these Specifications and in reasonably close conformity with the locations, lines, dimensions, and color shown on the Plans or established by the Engineer.

855.02 MATERIALS. Materials shall meet the requirements of Section 711.

855.03 EQUIPMENT.

A. *Extruded Application (Thermoplastic).* The material shall be applied to the pavement by the extrusion method wherein one side of the shaping die is the pavement surface and the other three sides are contained by, or are part of, suitable equipment for heating and controlling the flow of material. Extrusion of the material above the pavement surface will not be permitted.

All parts of the equipment which come in contact with the material shall be easily accessible for cleaning and maintenance. Conveying parts between the main reservoir and the shaping die shall not be allowed to clog up. All mixing and conveying parts up to and including the shaping die shall maintain the material at the plastic temperature and assure the continuous uniformity in the dimensions of the stripe. The equipment shall be so designed to insure uniform film thickness in the range of 3/32 inch minimum to 3/16 inch maximum.

The shaping die shall include a cutoff device remotely controlled to provide clean, square stripe ends and to provide a method of applying skip lines. The use of pans, aprons, or similar appliances which the die overruns will not be permitted. The top dressing of glass spheres shall be applied at the rate of approximately one pound per 100 feet of 4 inch wide line and in a manner which will firmly imbed them into the line surface at least 1/2 the diameter of the larger gradation sizes.

B. *Mechanical Application (Preformed Plastic Tape).* Preformed pavement line markings shall be installed with a mechanical applicator which shall be capable of placing pavement lines in a neat, accurate and uniform manner. The mechanical applicator shall be equipped with a film cutoff device and with measuring devices which automatically and accumulatively measures the length of each line actually placed to within a tolerance of +2 percent.

855.04 CONSTRUCTION METHODS.

A. *Surface Preparation.* In order to insure maximum possible adhesion, the Contractor shall clean off all dirt, glaze, grease, curing compound, or other foreign materials from the surface where lines are to be applied.

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The removal of existing striping will be at the discretion of the Engineer and will be measured and paid for under Section 859.

To insure the satisfactory performance of plastic pavement markings, new portland cement concrete pavement shall be sandblasted to remove the curing compound from the surface on which pavement markings are to be applied. Sandblasting may be done seven days after placement of the concrete surface unless otherwise directed by the Engineer. Payment of this operation will be included in Subsection 855.06.

On all portland cement concrete surfaces and on asphalt surfaces in place over 12 months, a liquid seal coat shall be applied to the area which is to be striped. The seal coat shall be the type that is compatible with the plastic material used and the surface to which it is applied.

Plastic pavement markings shall not be placed over longitudinal joints unless special written authorization is given by the Engineer for necessary exceptions.

B. Application of Markings.

1. Hot Applied Plastic Pavement Markings. Hot applied pavement markings shall be applied straight and true by the extrusion die method. Lines shall have sharp edges, uniform thickness, good adhesion, and uniform reflectance of a high level. To insure the best possible adhesion, the compound shall be installed in a melted state at temperature of 400° F to 450° F, measured at the pavement surface, and in accordance with the manufacturer's recommendations.

The application of hot applied thermoplastic markings shall be done only on clean dry pavement having a road surface minimum temperature of 55° F and rising.

The drying time shall be defined as the minimum elapsed time after application when the stripe shall have and retain the characteristics required and after which time normal local traffic will leave no impression or imprint on the new stripe. The minimum drying time shall not exceed two minutes at 50° F at a maximum relative humidity of 70 percent when applied at 3/16 inch thickness or one minute when applied at 3/32 inch thickness.

Thermoplastic material used under this Specification shall be so compounded and applied as to retain for the life of the stripe, the original characteristics of the bond to the surface, ability to resist distortions by traffic impact or normal climate changes, and resistance to natural discoloration.

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- 2. Cold Applied Plastic Pavement Markings.** Pavement markings which are preformed of reflectorized plastic material and applied cold to the surface shall be coated with a factory-applied, pressure-sensitive adhesive.

The material shall adhere to asphalt and concrete surfaces when applied according to the manufacturer's recommendations at surface temperature of 65° F and rising. If the markings must be applied when the surface temperature is below 65° F but not below 50° F, the markings are to be applied in strict accordance with the manufacturer's recommended procedures and/or other special instructions.

The application of the reflectorized plastic markings shall be without the use of heat, solvents, or extra adhesives of any nature except that a surface sealer is required on portland cement concrete surfaces as indicated in these Specifications.

- 3. Inlaid Installation of Preformed Plastic Tape.** When the inlaid method is to be used, the markings shall be applied after the newly placed bituminous concrete pavement has been adequately compacted and when the bituminous concrete pavement has attained a temperature range of 155° F to 125° F.

The preformed pavement markings shall be inlaid into the bituminous concrete surface by means of a mechanical roller. The mechanical roller shall be of sufficient weight capacity to inlay the preformed pavement marking to a minimum depth of 65 percent of the material thickness and to not more than 80 percent of the material thickness while the temperate range of the bituminous concrete is within 155° F to 125° F. In the event the inlaid preformed pavement markings are distorted by the Contractor's operations, they fail to provide a uniform appearance or they are installed improperly, such inlaid pavement markings shall be repaired or replaced at the Contractor's expense in a manner approved by the Engineer. The inlaid preformed pavement markings shall be installed in the finished surface of the bituminous concrete pavement work prior to conclusion of each day's work.

855.05 METHOD OF MEASUREMENT. Traffic stripe (plastic) will be measured by the linear foot of 4-inch wide traffic stripe material actually placed or the equivalent 4-inch wide stripe when a narrower or wider stripe is specified in the Plans. Where arrows, words and symbols are placed, they will be measured by each unit.

855.06 BASIS OF PAYMENT. Accepted traffic stripe (plastic), measured as provided above, will be paid for at the contract unit price for:

A. Traffic Stripe (Plastic) (4-inch wide)	Lin. Ft.
B. Traffic Stripe (Plastic) (Arrows)	Ea.
C. Traffic Stripe (Plastic) (Words)	Ea.
D. Traffic Stripe (Plastic) (Symbols)	Ea.

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E. Traffic Stripe (Plastic) (Tape) (4-inch wide)	Lin. Ft.
F. Traffic Stripe (Plastic) (Tape) (Arrows)	Ea.
G. Traffic Stripe (Plastic) (Tape) (Words)	Ea.
H. Traffic Stripe (Plastic) (Tape) (Symbols)	Ea.

which shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

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856.00 CONSTRUCTION TRAFFIC STRIPE

856.01 DESCRIPTION. This work shall consist of furnishing materials and placing traffic stripe on detours and roadways on which traffic is maintained during construction in accordance with these Specifications and in reasonably close conformity with the locations, lines and dimensions shown on the Plans or established by the Engineer. The use of paint with glass beads or reflective pavement striping tape for traffic stripe shall be optional, and they will be considered equal in measurement for payment. The use of removable pavement marking tape will be as specified on the Plans or as directed by the Engineer.

856.02 MATERIALS. Materials shall meet the requirements of Section 711.

856.03 EQUIPMENT. The paint machine and bead dispenser shall meet the requirements of Subsection 854.03. The application of reflective pavement striping tape and removable pavement marking tape shall be in accordance with the manufacturer's recommendation. During the period of application the pavement surface shall be dry and the atmospheric temperature shall be above 50° F.

856.04 CONSTRUCTION METHODS.

- A. Detours.** Striping of detours, including lane lines and edge lines, shall be completed before the detour is opened to traffic. When restriping of detours is necessary as determined by the Engineer, the restriping shall start within 24 hours (weather permitting) after the Contractor is notified by the Engineer.
- B. Stage Construction.** When roadways are being resurfaced in successive stages, striping shall be done prior to opening to traffic in a manner as shown on the Plans or as directed by the Engineer.

When on multi-lane divided highways, they shall be striped before opening to traffic as shown on the Plans.

Any detour striping that would conflict with the permanent striping shall be removed in a manner acceptable to the Engineer.

When additional striping is necessary due to overlays, redirection of traffic, or restriping due to wear, or other reasons as determined by the Engineer, the striping shall start within 24 hours after the Contractor is notified by the Engineer.

Removable pavement marking tape shall be installed in accordance with the manufacturer's recommendations as approved by the Engineer. The pavement

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surface shall be dry at the time of pavement marking application. The Contractor shall remove all dirt, debris, loose particles and heavy oil residues from the road surface application areas immediately prior to the installation of pavement markings.

All removable pavement marking tape shall present a uniform appearance and shall be clearly visible during the day and night for traffic control. Pavement markings which fail to provide a uniform appearance or which fail to be clearly visible during the day or night shall be corrected by the Contractor in a manner acceptable to the Engineer and at no additional cost to the Department.

When removable pavement markings are no longer required, as approved or determined by the Engineer, the pavement marking film shall be neatly removed. Additional pavement markings may be installed as necessitated by traffic conditions, as approved or determined by the Engineer. Pavement marking tape removed shall be disposed of by the Contractor upon removal.

The removal of painted stripe and plastic stripe will be accomplished and paid for in accordance with Section 859. The removal of removable pavement marking tape will not be paid for separately and will be included in the unit price for that material.

856.06 BASIS OF PAYMENT. Traffic stripe, measured as provided above, will be paid for at the contract unit price for:

A. Construction Traffic Stripe (Paint)	Lin. Ft.
B. Removable Pavement Marking Tape (4 wide)	Lin. Ft.
C. Removable Pavement Marking Tape (Arrows)	Ea.
D. Removable Pavement Marking Tape (Words)	Ea.
E. Temporary Pavement Marking Tape (4 wide)	Lin. Ft.

which shall be full compensation for road surface preparation, disposal of waste materials, and for all materials, labor, tools, equipment and incidentals to complete the work as specified.

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857.00 PAVEMENT MARKERS

857.01 DESCRIPTION. This work shall consist of furnishing and installing pavement markers of the class and type specified on the Plans, at the locations shown on the Plans or directed by the Engineer, and in conformity with these Specifications.

857.02 MATERIALS. Materials shall meet the requirements of Section 736.

857.03 EQUIPMENT. The equipment used for mixing and application of epoxy resin adhesive shall meet the requirements of AASHTO M 237.

857.04 CONSTRUCTION METHODS. The portions of the highway surface to which the marker is to be attached shall be free from dirt, curing compound, grease, oil, moisture, loose or unsound pavement or any other material which might affect the attachment of the marker to the pavement. On portland cement concrete pavement, the area to which the marker is to be affixed shall be prepared by sand blasting or wire buffer immediately prior to placement of the marker.

The Contractor shall follow the installation procedure recommended by the manufacturer of the marker. The markers shall be firmly affixed to the surface in such a manner that they will not be displaced under traffic.

The installation of the markers shall be such that the color of the marker housing is compatible with the color of the traffic stripes they are to supplement or replace.

Reflective pavement markers shall be placed at the designated location in such a way that the color of the reflected light is in accordance with the Plans, details or as directed by the Engineer.

If the road is open to public travel during the progress of work, the Contractor shall operate his equipment and store his materials and supplies in such a manner as to cause a minimum of hazard and inconvenience to the traveling public.

Any damage to the pavement or other facilities caused by the operation of the Contractor's equipment shall be repaired by the Contractor or at his expense.

857.05 METHOD OF MEASUREMENT. Pavement markers installed as directed and accepted will be measured by counting separately the number of various classes and types of markers.

Pavement markers shall be divided into classes and types for measurement and payment as follows:

- Class A – Reflective
 - Type 1 – Monodirectional
 - Type 2 – Bidirectional

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Class B – Non-reflective Ceramic
Yellow
White

Class C – Reflective, all weather
Type 1 – Monodirectional
Type 2 – Bidirectional

On reflective markers the color of the marker body other than the reflective face shall be neutral or match the reflector face. On bidirectional markers the color of the marker body shall be neutral or split to match the reflective faces.

The reflector unit for the Class C markers shall be affixed to the casting with an adhesive material which is molded to and is an integral part of the reflector unit. The section of the casting where the reflector unit is to be attached shall be brushed with a coat of primer furnished by the manufacturer immediately prior to attaching the reflector unit. The manufacturer's recommendations shall be closely followed.

The surfaces of the casting shall be free of rust, scale, dirt, oil, grease or other foreign material which might adversely affect the bond of the adhesive used to affix the marker to the pavement surface.

857.06 BASIS OF PAYMENT. Accepted pavement markers, measured as provided above, will be paid for at the contract unit price for:

A. Pavement Markers, Class A, Type 1	Ea.
B. Pavement Markers, Class A, Type 2	Ea.
C. Pavement Markers, Class B, Yellow	Ea.
D. Pavement Markers, Class B, White	Ea.
E. Pavement Markers, Class C, Type 1	Ea.
F. Pavement Markers, Class C, Type 2	Ea.

which shall be full compensation for furnishing all materials, preparation and installation and for all labor, equipment, tools and incidentals necessary to complete the work.

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859.00 REMOVAL OF PAVEMENT MARKINGS

859.01 DESCRIPTION. This work shall consist of the removal of traffic stripe or other pavement markings in accordance with these Specifications at the locations shown on the Plans or as designated by the Engineer.

859.03 EQUIPMENT. Equipment used for this removal of the markings may be of any type that will not materially damage the surface or texture of the pavement material.

859.04 CONSTRUCTION METHODS. Pavement markings shall be removed to the fullest extent possible without damage to pavement surface. All sand or other material deposited on the pavement as a result of the removal operation shall be removed as the work progresses. Where blast cleaning is used for the removal of the pavement markings and such removal operation is being performed within ten feet of a lane under use by the traveling public, the residue including dust, shall be removed immediately by a vacuum attachment operated concurrently with the blast cleaning operation or by other methods approved by the Engineer.

Any damage deemed appreciable by the Engineer shall be repaired by the Contractor at his own expense by methods acceptable to the Engineer. Nothing in these Specifications shall relieve the Contractor from his public relations and responsibilities as set forth in Section 107.

Painting over or blotting out the existing pavement markings is not considered to be an acceptable method of removal and will not be considered for measurement as removal.

859.05 METHOD OF MEASUREMENT. Traffic stripe or pavement marking removal will be measured by the linear foot of 4-inch wide traffic stripe where a narrower or wider stripe is to be removed or by the each where an arrow, word, or symbol is to be removed.

859.06 BASIS OF PAYMENT. Except where otherwise specified on the Plans, removal of pavement markings, measured as provided above, will be paid for at the contract unit price for:

- | | |
|--|----------|
| A. Pavement Marking Removal (Traffic Stripe) | Lin. Ft. |
| B. Pavement Marking Removal (Arrows) | Ea. |
| C. Pavement Marking Removal (Words) | Ea. |
| D. Pavement Marking Removal (Symbol) | Ea. |

which shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

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880.00 CONSTRUCTION SIGNING AND TRAFFIC CONTROL

880.01 DESCRIPTION. This work shall consist of furnishing and erecting signs, lights, barricades and devices as shown on the Plans or as required by the Engineer or as proposed by the Contractor and approved by the Engineer.

880.02 MATERIALS.

A. Construction Signing and Traffic Control Materials. Materials for construction signing and traffic control shall meet the requirements specified as follows:

1. *Signs and Barricades.* The supports and sign blanks may be either metal, wood or plastic, the only requirement being satisfactory performance. All signs and barricades shall be reflectorized whether for day or night use. Reflectorization of signs and barricades shall be by means of wide-angle flat top reflective sheeting meeting the requirements of Subsection 719.04.

All sign messages and symbols shall be constructed in accordance with the Manual on Uniform Traffic Control Devices and the Oklahoma Department of Transportation Sign Detail Standards.

2. *Signs 33.0 S.F. and Over.* Signs 33.0 square feet and over shall be constructed of extruded aluminum or galvanized steel. All signs in this item which are to be ground-mounted, shall be breakaway design and installed in accordance with the latest revision of the following standard drawings GMS-1, FGS-1, GFS-2 and SPA-1. Installation locations shall be approved by the Engineer prior to construction. Due to the temporary nature of these signs, no reinforcing steel will be required in the sign footings. Installation of this item may also include placement on existing overhead sign structures and will be shown on the Plans.

All signs in this item shall be reflectorized in accordance with current specification. Sign color and specific design shall be as shown on the Plans.

3. *Barricade Warning Lights.* Barricade warning lights shall meet the requirements of Section 6E-5, Manual on Uniform Traffic Control Devices.
4. *Advance Warning Devices.* The advance warning devices shall consist of the following components:
 - a. A sign panel with amber-colored, sealed-beam lamps attached, meeting the requirements of Section 6E-9, Manual on Uniform Traffic Control Devices.

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- b. A circuitry control unit.
- c. A mounting frame.

The face of the panels which are exposed to oncoming traffic shall be a non-reflective black finish. The level of intensity of light displayed by the sealed beam units shall be changed through means of the control unit for either high intensity for day or reduced for night operations. All sealed beam units shall display essentially the same intensity of light for a given intensity setting.

Larger panels may be substituted for smaller panels at the discretion of the Contractor, but smaller panels may not be substituted for larger panels.

The sign panel shall be supported on a mounting frame such that when displayed to oncoming traffic, the bottom edge of the panel shall be not less than 7 feet above the roadway surface.

The frame shall support the sign panel with sufficient strength to resist an 80-mile per hour sustained wind, with 104-mile per hour intermittent gusts from any direction. The advance warning device shall be mounted in such a manner that the panel can be rotated on a horizontal axis so as to be hidden from the view of on-coming traffic when not in use. All mobile advance warning devices shall be on pneumatic-tired vehicles.

The flashing lights on the advance warning device shall be operated from a dependable power source and shall have a separate auxiliary source of power immediately available. At least one power source on a mobile advance warning device shall be a self-contained source, either battery or electric generator operated.

The advance warning device shall contain a special circuitry control unit. The circuitry control unit shall be a solid-state electronic unit with four modes which shall contain switching controls for operator selection as follows:

1. Pass Right-sequential chevrons or flashing arrow.
2. Pass Left-sequential chevrons or flashing arrow.
3. Pass Either Side-the outermost chevrons, one at either end of the panel with the apex of each chevron pointing toward the nearest panel edge.
4. Caution-four or more lamps, arranged in a pattern which will not indicate a direction.

B. *Sampling and Testing.* Tests will not ordinarily be made by the laboratory on the above materials, but the materials furnished shall be recognized

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standard products and the manufacturer of such products shall furnish the Engineer a certificate of compliance with these Specifications supported by the appropriate test reports.

880.03 CONSTRUCTION METHODS. Signs, lights and barricades may be placed on either portable or fixed supports as project requirements dictate.

Traffic control devices shall meet the requirements of the current Manual on Uniform Traffic Control Devices, published by the U. S. Department of Transportation, as pertains to shape, size, color, mounting height and placement.

When, in the opinion of the Engineer, any sign or other device which has been damaged, needs cleaning, or has deteriorated to the extent it is no longer effective, it shall be cleaned or replaced immediately as required. The Controller will designate at least one person to be on call 24 hours a day to respond to emergency traffic control needs.

880.04 CONSTRUCTION METHODS. Signs, lights and barricades may be placed on either portable or fixed supports as project requirements dictate.

Traffic control devices shall meet the requirements of the current Manual on Uniform Traffic Control Devices, published by the U. S. Department of Transportation, as pertains to shape, size, color, mounting height and placement.

When, in the opinion of the Engineer, any sign or other device which has been damaged, needs cleaning, or has deteriorated to the extent it is no longer effective, it shall be cleaned or replaced immediately as required. The Contractor will designate at least one person to be on call 24 hours a day to respond to emergency traffic control needs.

880.05 METHOD OF MEASUREMENT. Each sign, barricade, light, drum, advance warning device, or other traffic control device will be measured by the unit, complete in place, each calendar day the device is required and is in place in an acceptable condition and position to meet all of the above requirements. Measurement for payment will begin on the day that signs and other devices are in place for traffic control and direction. The Contractor will be required to furnish a log of the signing and other traffic control devices and this log will be updated throughout the life of the project to confirm the addition or deletion of individual traffic control items. Prior to each pay period the traffic control devices will be physically counted to substantiate the log. The traffic control devices will be monitored daily by the Contractor to evaluate their physical condition. When signs and devices are not needed for traffic control, they will not be measured, even though left in place. During non-working periods such as holidays, Sunday, etc., the log of signs in place and measured for payment on the day preceding and on the day following such down time will be used to determine the signs to be paid for. When it is necessary to move an item from one location to another, it will be measured for payment only one time on the day of movement.

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The necessary flags, flagman signs and jackets, posts, traffic cones, and other incidental items included in a detour or other traffic control system or installation, as shown on the Plans or as required by the Engineer, will not be measured for payment, but their costs shall be included in the price of other bid items.

Signs and other traffic control devices will not be measured for payment during any time the Contractor is being charged for liquidated damages. This in no way relieves the Contractor from his responsibility for providing signing on the project or maintaining the required log until it has been completed and accepted. Such signing will be at his own expense.

During any period that contract time is suspended in accordance with Subsection 108.07, any traffic control devices required for the safety of the motoring public will continue to be measured and paid for.

Quantities included in the Plans for traffic control items are estimated quantities based upon a given sequence of construction and schedule of work and should not be considered as definite quantities for final payment. The quantities computed for final payment will be based on daily measurements recorded and approved by the Engineer.

880.06 BASIS OF PAYMENT. Signs and other traffic control devices, measured as provided above, will be paid for at the contract unit price for:

A. Advance Warning Device (Type A)	Sign Day
B. Advance Warning Device (Type B)	Sign Day
C. Advance Warning Device (Type C)	Sign Day
D. Signs 0 to 6.25 SF	Sign Day
E. Signs 6.26 to 15.99 SF	Sign Day
F. Signs 16.00 to 32.99 SF	Sign Day
G. Signs 33.0 SF & Over	Sign Day
H. Barricades (Type I)	Sign Day
I. Barricades (Type II)	Sign Day
J. Barricades (Type III)	Sign Day
K. Wing Barricades	Sign Day
L. Vertical Panels	Sign Day
M. Type A Light	Sign Day
N. Type B Light	Sign Day
O. Type C Light	Sign Day
P. Drums	Sign Day
Q. Tube Channelizers	Sign Day

which shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified. Unless otherwise designated on the Plans or special provisions all traffic control devices under this item will remain the property of the Contractor upon completion of the project.