SECTION 800 – TRAFFIC CONTROL DEVICES AND LIGHTING

SECTION 801 – TRAFFIC CONTROLS FOR CONSTRUCTION AND MAINTENANCE OPERATIONS

801.01 Description

This work shall consist of furnishing, placing, and maintaining signs, barricades, temporary pavement markings, and other traffic control devices at construction and maintenance operations in accordance with 105.03.

MATERIALS

801.02 Materials

Materials shall be in accordance with the following:

Coarse Aggregate, Class D or Higher, Size No. 73 904
Construction Warning Lights.....923.03
Delineator Posts 910.15
Delineators 926.02
Field Paint 909.04
Flashing Arrow Sign 923.04
Flexible Delineator Posts 926.01
Pavement Marking Materials.....921
Steel Posts 910.14
Temporary Barrier Delineator.....926.02(d)
Temporary Highway Illumination Materials 807
Temporary Panel Signs 919.01
Traffic Signal Materials and Equipment.....922
Traffic Signs.....802
Tubular Marker 923.06
Wood Sign Posts .....911.02(e)
Worksite Speed Limit Sign Assembly 923.05

Non-ground mounted temporary traffic sign backing material and supports shall both be certified to meet NCHRP 350 crash test standards and approved for use by the FHWA. Roll-up materials will not be allowed. A copy of the FHWA acceptance letter shall be provided to the Engineer upon request.

The background of construction signs shall be reflective sheeting in accordance with 919.01(b)1. The sheeting type used for construction signs shall be the same for the entire project. Reflective sheeting for drums shall be in accordance with 919.01(b)1. Effective on project lettings after July 1, 2006, the background for all construction signs shall be fluorescent orange reflective sheeting.

Steel sign posts need not be galvanized.

Wood posts for temporary panel signs shall be dense southern yellow pine or design computations shall be provided to the Engineer identifying the type of wood and

verifying the location and size of the holes to be drilled through the posts to provide break-away capability.

All temporary traffic control devices which will become the property of the Department shall be a new product at the time of final acceptance.

The basis for use for traffic paint; durable pavement marking materials; temporary marking tape type II; glass beads; barrels; barricades; construction warning lights; steel posts; temporary panel signs; traffic signs, except non-ground mounted signs; tubular markers; and wood sign post used for temporary traffic control will be visual inspection.

The connecting bolt or threaded rod used to connect adjoining sections of temporary barrier wall shall have a tensile strength of 120,000 psi (827 MPa). The spacers used between adjoining sections of temporary barrier wall shall be in accordance with ASTM A 36 (ASTM A 36M) with a tensile strength of 58,000 psi (400 MPa).

CONSTRUCTION REQUIREMENTS

801.03 General Requirements

The applicable requirements of the MUTCD shall apply to the installation and materials for traffic control devices subject to the requirements of 107.08 and 107.12. When the plans do not include a maintenance of traffic plan, the Engineer will provide such a plan to the Contractor. The Contractor shall be responsible for the field layout, placement, operation, maintenance, and removal of temporary traffic control devices. A worksite traffic supervisor certified by the American Traffic Safety Service Association, ATSSA, or approved equal certifying organization, shall direct all field layout, placement, operation, maintenance, and removal of temporary traffic control devices. The certified worksite traffic supervisor, CWTS, shall ensure that all traffic control devices, except temporary concrete barrier, meet acceptable standards as outlined in the plans, specifications, and ATSSA's "Quality Standards for Work Zone Traffic Control Devices" prior to installation. The CWTS shall also, prior to installation, ensure that all traffic control devices can be installed in accordance with the plans, specifications, and the MUTCD. All problems shall be reported to the Engineer so a resolution can be worked out prior to installation. The field layout will be reviewed and concurred with by the Engineer prior to placement of any temporary traffic control devices. The CWTS shall be present for the initial setup and all phase changes during the life of the project. The CWTS may designate responsible Contractor personnel to perform day to day operation and maintenance of the temporary traffic control devices. These responsible personnel shall work under the direction of the CWTS and their names shall be given to the Engineer on the project. A copy of the CWTS's certification shall be provided to the Engineer prior to the start of construction or placement of temporary traffic control devices or if the worksite traffic supervisor changes.

Regulatory control devices shall be erected only as directed.

Advisory speeds to be posted will be determined by the Department.

The names and telephone numbers of the superintendent and one other responsible employee shall be furnished. Such employees shall be on call or available at

night, on weekends, or during other non-working periods to repair or replace all traffic control devices which may become damaged or inoperative.

When traffic lanes are restricted and when specified as a pay item, a patroller shall inspect and maintain traffic control devices. The patroller shall patrol the construction zone and shall immediately correct, maintain, and repair traffic control devices or notify the Contractor designated persons for immediate repair to such traffic control devices. A full time patroller shall be on duty during periods when work is not in progress.

Temporary traffic control devices shall be maintained continuously, except as described herein, to ensure visibility and to protect the public. All reflective sheeting backgrounds and lights shall be kept clean of foreign matter. The Contractor shall complete a "Traffic Control Device Report" weekly. This report is supplied in the Proposal Book for the contract and is to insure that the traffic control devices are looked at daily. The report does not always need to be filled out by the CWTS but must be reviewed by the CWTS for completeness and accuracy. The report shall be signed by the person who filled it out and initialed by the CWTS that it was reviewed. The Engineer will sign and date the report when received. The Engineer will not be responsible for the report's completeness and accuracy. If the CWTS feels that a situation exists where the temporary traffic control devices do not need to be checked daily for a certain period of time, the CWTS and the Engineer must agree on how often they should be checked.

Except for construction warning lights and temporary signals, the ATSSA brochure titled Quality Standards For Work Zone Traffic Control Devices will be used as a guide to determine if temporary traffic control devices are Acceptable, Marginal, or Unacceptable as defined in the brochure. Upon initial setup and phase changes of temporary traffic control devices, all individual devices shall be of the Acceptable classification. A device not completely covered or removed when the message does not apply or when directed, will be considered unacceptable.

A temporary traffic control device will be deemed to be in non-compliance when considered Unacceptable. A type of temporary traffic control device will be deemed to be in non-compliance when 25% or more of the individual devices are considered Marginal. Damages may be assessed in accordance with 105.14 for non-compliance.

Non-compliance of construction warning lights will be in accordance with 801.14.

All barricades, signs, or flashing arrow signs shall be moved from one location and re-erected at another location as shown on the plans or as directed.

Where two-way traffic is to be maintained on a one-way pavement, and where the existing shoulders on such roadway are earth, aggregate No. 73 shoulders shall be compacted in accordance with 303.06 as shown on the plans. Compacted aggregate shoulders shall remain in place unless subsequent construction activities on the contract require its removal.

Temporary drainage structures, temporary concrete median barrier units, and other temporary devices required and used for traffic maintenance shall remain the property of the Contractor.

801.04 Construction Signs

Construction signs shall include the typical sign standards or posts which support the sign, all necessary hardware, and specified construction warning lights.

A route or lane closure notice sign shall consist of a construction sign type A, in accordance with 801.04(a), which indicates route or lane closure. The sign shall be mounted for a maximum of 14 calendar days and a minimum of seven calendar days before the closure date shown on the sign. The sign shall be removed when the route or lane is closed.

Trailers in accordance with 910.14(f) may be used as supports for portable construction signs. The trailer shall be located to hold the sign in a proper position. The position of the tongue shall be so as to cause no hazard to traffic. Wheel chocks other than sandbags shall not be used. The tongue may be pinned to reduce wind-induced rolling if designed to pull up or break from vehicle impact. During non-working hours, trailers with signs that do not apply to existing conditions shall be stored in accordance with 107.08(c).

Sign posts and their foundations shall be located and constructed to hold signs in a proper position; to resist swaying, turning, or displacement; and minimize the hazard to motorists. No rigidly fixed sign supports will be permitted in exposed areas where it would be practicable to utilize a breakaway or yielding type design. Signs shall be completely covered or removed when the message does not apply.

If the work on a project, or a portion thereof, is not active, and the roadway is open to unrestricted traffic, construction signs may be removed until work resumes. Removal of such signs shall not relieve the Contractor of responsibilities or liabilities described elsewhere herein.

Temporary mounted construction signs shall not be used for operations which affect traffic lanes or paved shoulders. Temporary mounted construction signs shall not be used or left in place during nighttime hours.

(a) Type A

A type A sign shall consist of a construction sign as detailed in the MUTCD or on the standard drawings which is 9 sq ft (0.84 m^2) or more in area.

(b) Type B

A type B sign shall consist of a construction sign as detailed in the MUTCD or on the standard drawings which is less than 9 sq ft (0.84 m^2) in area.

(c) Type C

A type C sign shall consist of a construction sign which is not detailed in the MUTCD or on the standard drawings and which is 9 sq ft (0.84 m^2) or more but less than 33 sq ft (3 m^2) in area.

(d) Type D

A type D sign shall consist of a construction sign which is not detailed in the MUTCD or on the standard drawings and which is less than 9 sq ft (0.84 m^2).

(e) Temporary Panel Sign

A temporary panel sign shall consist of a sign fabricated and constructed in accordance with 919.01 and which is greater than 33 sq ft (3 m^2). Temporary panel signs shall be mounted on wood posts as shown on the plans or as approved by the Department. External bracing shall not be used.

801.05 Detour Route Marker Assembly

Detour route marker assemblies shall be on a single post for a single route or may be on multiple posts for multiple routes. When two routes are being detoured across a common roadway, each route shall be shown by a separate detour route marker assembly. A detour route marker assembly-multiple route shall be used for three or more routes across a common roadway.

801.06 Road Closure Sign Assembly

Road closure sign assemblies shall be used at each road closure location where type III-A barricades or type III-B barricades are used. Road closure sign assemblies shall not be used within lane closures where adjacent lanes remain open to traffic, unless otherwise directed. Road closure sign assemblies may be required at other locations as directed.

Permanent road closure sign assemblies shall be left in place after the contract is completed and shall become the property of the Department. They shall be installed just prior to final acceptance of the contract. Supports shall be painted with white field paint for wood.

801.07 Barricades

Barricades shall include rails, posts, and all incidentals necessary to complete this part of the work.

High intensity reflective sheeting shall be placed on specified rails of all barricades. The colors for temporary barricades shall be orange and white, and for permanent barricades red and white.

All type III barricades shall be skid mounted within pavement, shoulder, or sidewalk areas, and on ground mounted posts in all other areas. Type III barricades shall be used on all slopes which are 3:1 or flatter for roadway closures.

(a) Type III-A Barricade

The type III-A barricade shall have rails which are reflectorized on one side and shall be used for roadway closures and lane closures where traffic can approach from only one side.

(b) Type III-B Barricade

Type III-B barricades shall have rails which are reflectorized on both sides and shall be used for roadway closures and lane closures where traffic can approach the barricade from both sides.

(c) Permanent Type III Barricade

Permanent type III barricades shall be 10 ft (3.0 m) sections and shall be left in place after the contract is completed, and shall become the property of the Department. Permanent type III barricades shall be installed just prior to final acceptance of the contract. All non-reflectorized wood and non-galvanized steel shall be painted with white field paint. Such barricades shall otherwise be in accordance with 801.07(a).

801.08 Cones and Tubular Markers

Cones shall be made of a material to withstand impact without damage to striking vehicles. They shall have a substantial base to restrict overturning. Cones and tubular markers shall be as shown on the plans.

Cones shall be used only during temporary activities where portability is advantageous and they remain in place and do not create a hazard to traffic. The use of cones in lieu of drums will be permitted during daylight hours unless otherwise directed.

Tubular markers shall be used for separating two-lane two-way traffic as shown on the plans or as directed.

Cones and tubular markers shall be secured in place either by weighting or adhesives. The use of metal bases will not be permitted.

801.09 Drums

Drums shall be molded orange polyethylene.

The shape of the drum shall appear basically cylindrical to the motorist from any direction in any given application. The top outside diameter shall not exceed the bottom outside diameter. Drums shall be multisided, elliptical or have a flattened side to inhibit rolling.

The top section of the drum shall have at least one construction warning light mounting bracket. The minimum drum height is exclusive of lifting handles or construction warning light mounting brackets.

The drums shall stand on end, be stable against overturning, and shall be internally or externally ballasted to resist wind speeds of up to 50 mph (80 km/h) and gusts created by traffic. The weight (mass) of the ballast shall be 45-55 lb (20-25 kg). The top of the drum shall be free from openings. Internally ballasted and externally collar ballasted drums shall not be mixed in each continuous set-up.

Internal ballast shall be sandbags, a molded plastic base filled with sand and closed with a locking cover, or a solid rubber base. The internal ballast shall be placed in the lower 1/4 of the drum. The ballast device shall be self-draining.

The external ballast shall be two rubber tire base collars. The tire base collars shall have a circumferential contact with the road surface. The maximum diameter of the tire base collar shall not exceed 36 in. (900 mm). The height of two tire base collars at the outside edge shall not exceed 5 in. (125 mm). The rubber ballasting collars shall be clean cut, proper in size, black in color, and not curved up at the edges. The interior and exterior circumference of the collar shall not be slit or cut. Drums which are external collar ballasted shall not be used in situations where the width of the collar interferes with proper placement of the drum. The Department's Guidelines for External Ballast will be used for determining acceptability of rubber tire base collars.

Upon impact by a vehicle traveling at a speed of 55 mph (90 km/h), the drum and ballast device shall be of a type that permits the body of the drum to separate from the base, thus allowing vehicles to easily pass over the base.

Flexible encapsulated lens reflective sheeting shall be used to achieve reflectorization. Construction warning lights shall be used in accordance with 801.14 and as shown on the plans and shall be securely fastened to the mounting brackets. Signs shall not be mounted on drums.

Permanent drums shall be left in place after the contract is complete, and shall become the property of the Department. They shall be installed just prior to final acceptance of the contract.

801.10 Temporary Traffic Barriers

Temporary traffic barrier shall be one of the following four types as shown on the plans.

Type 1

Type 1 temporary traffic barriers shall be used to separate two-way traffic and shall be precast concrete in accordance with applicable requirements of 707 and 602 and as shown on the plans. Type 1 barriers may also be used to separate traffic from the work zone. The surfaces of individual precast units shall vary no more than 0.25 in. (6 mm) in 10 ft (3 m) from the specified cross section, as measured from a longitudinal straightedge. The maximum variation in the vertical and horizontal alignment of adjacent units shall be 0.25 in. (6 mm) across the joint, as measured from a 10 ft (3 m) longitudinal straightedge. Sections that have obvious defects or visual cracks shall not be used. Sections that develop any of these conditions during the contract shall be repaired with concrete or replaced within a reasonable amount of time.

Units precast after March 1, 2003 shall be clearly marked with the name or trademark of the manufacturer, the year of manufacture, and "INDOT". The markings shall be indented on an end or on the top of each barrier section. Units precast prior to 2003 shall not be used after January 1, 2012.

Type 2

Type 2 barriers may be used to separate traffic from the work zone. Type 2 temporary traffic barriers shall meet the appropriate test level 2 or 3 NCHRP 350 crash test standards and shall be approved for use by the FHWA. A 350 crash test letter of approval from the FHWA shall be provided the Engineer prior to placing the unit. The

unit selected shall be appropriate for the location considering the maximum posted speed limit on the project and the allowable area for deflection. The unit shall be installed according to the manufacturer's recommendations.

If concrete barriers are used as type 2 barriers, they shall be in accordance with the requirements for type 1 barriers.

Type 3

Type 3 temporary traffic barriers shall be those type 1 temporary traffic barriers that are to be left in place at the completion of the contract and shall become the property of the Department. They shall be in like-new condition at the completion of the contract. All necessary delineation and required anchor systems shall be left in place.

Type 4

Type 4 temporary traffic barriers shall be those types that are intended to be readily moveable to accommodate the shifting of traffic lanes on a daily basis to better facilitate the changing volumes of traffic during the peak hours of a day. Type 4 temporary traffic barriers shall meet the appropriate test level 3 NCHRP 350 crash test standards and shall be approved for use by the FHWA. A 350 crash test letter of approval from the FHWA shall be provided the Engineer prior to placing the unit.

(a) Placement

Temporary traffic barriers shall be located as shown on the plans or as directed. Temporary traffic barriers used to close a lane of traffic shall be flared at the rates as shown on the plans for the applicable regulatory speed within the construction zone. If field conditions are such that the required flare rate cannot be utilized, the tapered alignment may be altered, with approval, to a 10:1 flare rate with a 20 ft (6 m) minimum offset from the edge of the through traffic lane to the approaching end of the flared temporary traffic barrier. If field conditions are such that that the 10:1 flare rate cannot be utilized, the tapered alignment may be further altered, with approval, to a 6:1 flare rate with the 20 ft (6 m) minimum offset. Flare rates for ends of temporary traffic barriers at locations where a lane of traffic is not being closed to traffic or where the lane has already been closed shall be the same as above, however the minimum offset from the edge of the through traffic lane may be 10 ft (3 m). The use of flare rates sharper than those shown on the plans may require additional traffic control devices as directed.

Type 2 barriers shall not be intermixed with type 1 or type 3 barriers in any run. Type 2 barriers from different manufacturers shall not be intermixed in any run.

(b) Connection

Type 1 and type 3 barrier sections shall be connected as follows:

1. The adjacent barrier sections shall be placed end to end, with sufficient overlapping of the smooth bar hooks to allow placement of the connecting bolt or threaded rod and the top spacer.

2. The adjacent barrier sections shall then be moved in opposite directions for a sufficient distance to develop the maximum contact

between the smooth bar hooks and the connecting bolt or threaded rod.

3. The bottom spacer and nut shall then be placed as shown on the plans. The nut shall be sufficiently tightened to eliminate all gaps between the adjacent bolt heads, spacers, nuts, and washers which form the connection.

Type 1 and type 3 precast units which have previously been cast meeting earlier Department standards may be used. The Contractor will be allowed to mix type 1 and type 3 units in a run as long as the units are in good condition and the connecting devices are compatible. If units meeting earlier Department standards are used, a 1 in. (25 mm) bolt will be allowed to link the units together. The spacer detail shall, however, be in accordance with the current standard. Units cast after March 1, 2003 shall be linked with the 1 1/4 in. (30 mm) bolt.

Type 2 temporary traffic barriers shall be connected as recommended by the barrier manufacturer.

(c) Anchorage

Type 1 and type 3 temporary traffic barriers shall be anchored in accordance with the methods shown on the plans, at the locations described herein. Type 2 barriers shall be anchored as recommended by the barrier manufacturer and at locations described herein. Temporary concrete traffic barriers shall be anchored when located on or within 60 ft (18 m) of a bridge, and along tapered alignments. Anchoring at locations in addition to those described herein will be required when directed.

Chemical anchor systems with removable bolts, or mechanical anchors may be used to anchor type 1 barriers to bridge decks, concrete pavement, and concrete shoulders. Mechanical anchors may be ferrous or non-ferrous material. All anchors shall have a shear strength of 10,000 lb (44.5 kN) and an ultimate pullout strength of 6,500 lb (29 kN).

Non-ferrous mechanical anchors shall be installed such that the top end of the sleeve is a minimum of 2 1/2 in. (60 mm) below the final finished concrete surface.

Ferrous mechanical anchors shall be completely removed when no longer required. All damage to the pavement shall be repaired as directed.

Non-ferrous anchor sleeves and the chemical adhesive component of chemical anchor systems may remain in place when no longer required. The holes remaining in the pavement shall be filled with appropriate material as directed.

(d) Delineation

Type 1 barriers used to separate two-way traffic shall be delineated with top mounted temporary barrier delineators and with side mounted delineators. The top mounted delineators shall be two-sided, shall be yellow, and shall be placed on every other section of barrier wall (± 20 ft or 6 m spacing). The top mounted delineators shall

be mounted perpendicular to the direction of traffic flow. The side mounted delineators shall be yellow and shall be mounted in accordance with 602.03(f).

Temporary traffic barriers in locations other than separating two-way traffic shall be delineated with either type C construction warning lights or top mounted temporary barrier delineators and with side mounted barrier delineators. The type C lights or the top mounted barrier delineators shall be spaced at the number of feet equal to (number of meters equal to 0.3 times) the number of miles per hour in the posted speed limit with a minimum spacing of 20 ft (6 m). Bi-directional lenses will be required on the warning lights when the barrier is adjacent to a lane that is carrying alternating one way traffic. The color of the barrier delineators shall be white when located on the right side of the traffic lane, and yellow when located on the left side of the traffic lane. The color of the barrier delineators shall be white when located adjacent to a lane that is carrying alternating one-way traffic.

Where the temporary traffic barrier is located along a tapered alignment and is located behind drums or other reflective delineation devices, the type C construction warning lights and barrier delineators shall not be used.

(e) End Treatment

Where possible, the ends of temporary traffic barriers shall be flared in accordance with 801.10(a). Where conditions do not allow the temporary traffic barrier to be flared in accordance with 801.10(a), appropriate end treatments shall be incorporated to protect vehicles from the ends of the barriers. The end treatments shall have re-direct capability and shall meet the appropriate test level 2 or 3 NCHRP 350 crash test standards and be approved for use by the FHWA.

(f) Storage

No barrier segments shall be stored on the right-of-way unless written permission is given by the Department. Requests for permission to store traffic barrier segments on the right-of-way will not be accepted until after the contract has been awarded.

801.10.1 Construction Zone Energy Absorbing Terminal, CZ

The construction zone energy absorbing terminal, cz shall have passed NCHRP 350 level 3 crash test for all Interstate and other construction sites having a construction zone speed limit in excess of 45 mph and level 2 for non-Interstate construction sites having a construction zone speed limit of 45 mph or less. All energy absorbing terminal, cz shall have redirect capabilities and shall be approved by the FHWA. A copy of the crash test results and a copy of the FHWA approval letter shall be furnished to the Engineer prior to the installation of the unit. The Contractor may also use the Guard Rail Energy Absorbing Terminal cz, manufactured by Energy Absorption Systems, Inc.

The unit’s nose cover shall be reflectorized to provide improved visibility.

Assembly and installation of the unit shall be supervised or performed at all times by an installer trained and certified by the unit’s manufacturer. The size, assembly, and installation shall be in accordance with the manufacturer’s recommendations at the locations shown on the plans. When required for bi-directional traffic protection, transition panels and all other necessary hardware shall be included in the installation. A

copy of the installer's certificate shall be provided to the Engineer prior to the start of work.

The Contractor shall provide the Department with original copies of all necessary current manufacturer's installation manuals and shop drawings prior to beginning installation work. Shop drawings shall be a minimum of 22 in. x 34 in. (560 mm x 865 mm) in size. No installation work shall begin prior to the Department's receipt of such manuals and drawings. Such manuals and drawings will remain the property of the Department. If there is a discrepancy between shop drawings and the plans, the shop drawings shall govern.

Sufficient spare parts or complete units shall be stored in a safe, convenient, nearby location. Such standby materials are not shown in the Schedule of Pay Items. The standby materials shall be utilized to repair or replace damaged units in the shortest time possible. Standby materials used in the repair of damaged units shall be replaced within 24 h of their use.

801.11 Temporary Crossovers

Temporary crossovers shall be either type A or type B as shown on the plans and shall be constructed in accordance with the applicable sections of 207, 402, or 502. When required to maintain median drainage, a 15 in. (375 mm) diameter pipe shall be placed at the centerline of the median under the crossover. If the crossover is to remain in place for future construction, the pipe shall have appropriate grated box ends in accordance with 715.

The pavement structure for the temporary crossover shall be as shown on the plans.

Traffic control devices, including temporary pavement markings, shall be as shown on the plans. Separation of opposing vehicular traffic between two crossovers shall be as shown on the plans.

Refurbishing of a temporary crossover shall consist of the removal of drums or earth cover from an existing temporary crossover. The temporary crossover shall be patched and resurfaced as directed. Excavated soil resulting from the refurbishing operation, if not used as a part of the contract work, shall become the property of the Contractor. Removed drums will remain the property of the Department.

After construction is complete, and prior to the opening of all lanes to traffic, the temporary crossover shall be removed or closed.

Where guardrail is required to be removed for construction or refurbishing of crossovers, such removal and subsequent re-erection shall be done as shown on the plans or as directed.

Acceptance of HMA for temporary crossovers will be in accordance with 402.09.

801.12 Temporary Pavement Marking

Temporary pavement markings shall be in accordance with 808.04 and 808.05. However, the dashed line pattern used on center line and lane lines may be 4 ft (1.2 m) line segments on 40 ft (12 m) centers. Gore areas shall be marked by outline only and may be 5 in. (125 mm) wide lines. All temporary markings shall be maintained and replaced until they are no longer applicable.

Temporary markings placed on the final surface course shall be temporary marking tape type 1.

Where temporary pavement markings are to be placed on a pavement which has existing markings, the existing markings which conflict with the temporary markings shall be removed in accordance with 808.10.

When working under traffic, the temporary pavement markings shall be placed before opening the lane to traffic. This shall include, but not be limited to, the marking patterns of gore areas, outside edge line of deceleration and acceleration lanes, narrow bridge markings, lane reduction transitions, lane lines, centerlines, and transverse markings as appropriate.

If a pavement course is to be in place for a period greater than 14 calendar days, all temporary pavement markings shall be placed in accordance with 808.04 and stop lines shall be placed in accordance with 808.05. No-passing zones on all undivided two-way roadways shall be identified with signs and centerline markings.

If the temporary pavement markings are to be in service from December 1 through the following March 31, such markings shall be placed in the standard pavement marking pattern and applied prior to the suspension of the work, or within seven work days after the Contractor is directed to place the markings.

The prismatic reflectors shall be removed from snowplowable raised pavement markers which conflict with the temporary traffic marking pattern. Snowplowable raised pavement marker castings damaged by the removal of the reflector shall be replaced in accordance with 808.11. New prismatic reflectors shall be mounted on existing castings in accordance with 808.11 when the final traffic pattern is established.

Removal of temporary pavement markings shall be in accordance with 808.10.

(a) Temporary Pavement Marking Methods

Pavement markings shall be installed in accordance with 808.07.

1. Paint

Painted lines on new HMA courses shall require a second application of paint as soon as practical after the first application is dry.

2. Temporary Pavement Marking Tape

Temporary pavement marking tape shall be applied in accordance with the manufacturer's recommendations. Temporary marking tape shall be new type I or type II material.

All temporary pavement marking tape shall be removed prior to placement of an HMA overlay or final pavement markings.

a. Type I

Type I tape is a removable material. It may be used for longitudinal and transverse markings. It shall be used for longitudinal and transverse markings on the final surface.

Type I tape shall be removed without the use of solvents, grinding, abrasive blasting, or other methods which may damage the pavement. All visible adhesive residue shall be removed without use of solvents or grinding.

b. Type II

Type II tape is a non-removable material. It may be used on PCCP to be removed or overlaid with an HMA course greater than 110 lb/sq yd (60 kg/m^2). If it is placed on HMA pavement, the tape shall be removed prior to the recycling of the HMA material.

If it is necessary to remove type II tape, it shall be removed without the use of solvents. All damage to the pavement shall be repaired.

3. Temporary Raised Pavement Marker

The temporary raised pavement marker shall be grade 1 or grade 2. When used, it shall be a supplement to other temporary pavement markings. The color of the reflector shall be in accordance with the other temporary pavement marking. The color of the shell of the grade 1 marker shall be in accordance with the color of the other temporary pavement marking.

Temporary raised pavement markers shall be removed before the next layer of pavement is placed and before the final pavement markings are applied. All damage to the pavement shall be repaired.

4. Temporary Buzz Strips

Temporary buzz strips shall be a set of transverse markings. Durable marking material shall be used in accordance with 808.07(b). Temporary buzz strips shall be removed in accordance with 808.10 when no longer required or as directed.

(b) Quality Assurance Unit

A quality assurance unit for longitudinal line shall be 500 lft (150 m) on marked pavement in any combination or pattern, or portion thereof. A quality assurance unit for transverse marking shall be each. If a marking fails to be in accordance with the marginal standard as defined in the ATSSA Quality Standards for Work Zone Traffic Control Devices, the quality assurance assessment will be assessed in accordance with 801.03.

801.13 Temporary Illumination

The temporary highway illumination shall be in accordance with applicable requirements of 807 except as modified herein.

The electric energy necessary to power the luminaires on a continuous basis is the responsibility of the Contractor.

At completion of the contract work, the temporary illumination shall be removed and shall remain the property of the Contractor. After removal of the temporary illumination equipment, all holes and trenches shall be backfilled with B borrow.

801.14 Construction Warning Lights

Construction warning lights shall be portable, lens directed, enclosed lights that emit an amber color. All warning lights shall be mounted a minimum of 36 in. (900 mm) above the traveled way to the bottom of the lens, unless otherwise directed. Lights not working shall be repaired or replaced immediately. For each day that more than 5% of the required warning lights are not operating, a sum equal to $4.00 per non-working light will be deducted from the monies due the Contractor.

(a) Type A

Type A lights shall be low intensity flashing warning lights. These lights shall be visible on a clear night from a minimum distance of 3,000 ft (900 m) when there is no external illumination directly on or in the immediate vicinity of the light. They shall operate from dusk to dawn or when conditions exist which tend to obscure vision. Traffic control devices used for maintaining traffic will not require Type A warning lights during unobscured daylight hours.

(b) Type B

Type B lights shall be high intensity, flashing, warning lights. These lights shall be visible on a sunny day from a minimum distance of 1,000 ft (300 m) when viewed without the sun directly on or behind the light.

(c) Type C

Type C lights shall be steady burning warning lights. These lights shall be visible on a clear night from a minimum distance of 3,000 ft (900 m) when there is no external illumination directly on or in the immediate vicinity of the light. They shall operate from dusk to dawn or when conditions exist which tend to obscure vision.

(d) Vehicle Warning Lights

Vehicle warning lights shall be amber and shall be a strobe light or a flashing, oscillating, or rotating directed beam light. They shall be visible to all approaching traffic for a distance of 1,000 ft (300 m).

801.15 Electronic Devices

(a) Flashing Arrow Sign

Where specified, a flashing arrow sign shall be furnished, installed, and maintained. It shall be operated continuously, when necessary, to divert traffic.

The flashing arrow sign may be of the solar power assisted type only in stationary operations when the horizontal or vertical curvature in the road is such that motorists do not drive into and out of the beam width of the lighted arrow while within sight of the sign.

(b) Changeable Message Signs

This shall consist of furnishing, installing, and maintaining a trailer-mounted, portable sign upon which varying electronically generated messages will be displayed to traffic. The message being relayed to traffic shall be legible and easily understood for a minimum distance of 650 ft (200 m).

A malfunctioning sign shall be repaired or replaced within 24 h.

(c) Temporary Worksite Speed Limit Sign Assembly

This shall consist of furnishing and placing portable speed limit signs as shown on the plans or as directed in areas of work activity. The worksite speed limit flashing strobe lights shall be activated when the worksite speed limit is in effect. This shall be only where and while work is actually in progress and workers are present. Each strobe light shall be visible through a range of 120 deg when viewed facing the sign and shall have a minimum effective luminance of 2100 cd effective according to the manufacturer's literature, which shall be provided to the Engineer prior to use.

Wherever a permanent speed limit sign exists within the limits controlled by the worksite speed limit sign assemblies, additional worksite speed limit sign assemblies shall be placed next to the permanent signs.

The worksite speed limit shall not be used for the entire length of a roadway under construction unless there is actual work activity for the entire length of such roadway. It shall not be activated at the beginning of the day, for the entire day, if actual work is not being done all day in the work area.

The worksite speed zone signage shall be placed and maintained by the Contractor. The worksite speed limit will be 45 mph, or 10 mph below the posted speed limit for the roadway under construction, whichever is lower.

A worksite "Reduced Speed Ahead" sign shall be placed in advance of the first sign assembly when the reduction in speed limit is greater than 15 mph.

(d) Temporary Traffic Signals

This work shall consist of furnishing, installing, and maintaining temporary traffic signals in accordance with 805 except as modified herein.

Except as shown on the plans, all materials not furnished by the Department shall remain the property of the Contractor after work is completed and the equipment is removed.

The traffic signal equipment shall be as specified, but may be either new or used. Used equipment shall be in satisfactory working condition and will be approved prior to use.

Two signal heads shall be displayed for each approach. Signals shall be displayed overhead on a span, catenary, and tether utilizing an aircraft cable, unless otherwise directed.

Electric energy necessary to power the temporary signal is the responsibility of the Contractor. Prior to the start of construction, the schedule of activities shall be coordinated with the power company.

The Contractor shall obtain permits from local officials, companies, or individuals for the use of poles, right-of-way, or other property incidental to the installation of temporary signals. Although entering into the contract implies permission and authority to install conduit under pavement, sidewalks, and alleys, all damage to underground utilities or interruption of such service shall be the responsibility of the Contractor.

The location, spacing, and timing of signals will be determined by the Engineer.

An IMSA certified level II technician shall be available 24 h a day to respond within 2 h for the maintenance of the traffic signal equipment.

Signal cable may be extended across bridges through conduit which shall be attached to the underside of the coping. Type and spacing of clamps shall be approved prior to installation.

Conduit shall be steel or plastic. Flexible conduit will be an acceptable alternate for use as ground rod entry, magnetometer, or microloop installations.

The controller shall be solid state digital. When detection is required, the controller shall be traffic actuated solid state, digital.

Vehicle detection, if required, shall be installed as shown on the plans or as otherwise directed and shall be operational prior to signal activation.

801.16 Temporary Traffic Control Zone

A temporary traffic control zone is a work zone with frequently changing operation, a maximum duration of seven calendar days; mobile operation; or a temporary traffic stoppage.

Daytime lane closures on two-lane two-way roads shall be limited in length to a maximum of 1 mi (1.6 km) or the length of one-half day's operation, whichever is less, or as shown on an approved alternate traffic control plan.

(a) Temporary Traffic Control Signs

Temporary traffic control signs (TTCS) are construction signs in a temporary traffic control zone.

Trailer mounted TTCS shall be positioned such that the tongue and the method of pinning shall minimize the hazard to motorists. Wheel chocks other than sandbags shall not be used. During non-working hours, trailers with signs that do not apply to existing conditions shall be stored in accordance with 107.08.

TTCS shall not be mounted on barricades or other non-approved supports. When the vertical mounting height for TTCS is between 12 in. and 18 in. (300 mm and

450 mm) to the bottom of the sign, tripod supports may be used. When permitted for use, the signs on tripod supports shall be installed so that the angle from vertical does not exceed 30 degrees.

(b) Maintenance of Traffic for Mobile Operations

Signs, flagging, flashing arrow signs, and other required traffic control devices shall be furnished in accordance with the details shown on the plans or as directed. The Engineer reserves the right to stop work at any time to relieve traffic congestion.

(c) Traffic Control for Temporary Traffic Stoppage

Traffic shall not be permitted to pass directly beneath personnel or equipment working on an overhead structure. Traffic stoppage during an overhead operation shall not exceed 20 min at one time. There shall be enough time between consecutive stoppages to permit traffic to return to normal flow.

Three working days prior to commencing work which necessitates temporary stoppage of traffic, written notice shall be given to the Department and the Indiana State Police that highway traffic shall be stopped temporarily at a specific location, time, and date to accomplish specified work. Traffic shall be safely controlled during the stoppage. The following minimum requirements shall be met.

1. On Multi-Lane Divided Highways

Advance warning signs shall be located as specified or as otherwise directed. For each direction of road closure two flaggers shall be located at the site of the work and a minimum of two additional flaggers shall be used to warn approaching traffic.

2. On Non-Divided Highways

Advance warning signs shall be located as specified or as otherwise directed. For each direction of road closure, one flagger shall be located at the site of the work and a minimum of one additional flagger shall be used to warn approaching traffic.

801.17 Method of Measurement

Construction signs, detour route marker assemblies, detour route marker assemblies-multiple routes, temporary worksite speed limit sign assemblies, road closure sign assemblies, temporary changeable message signs, and temporary raised pavement markers will be measured by the number of units installed, maintained, and removed.

Temporary panel signs will be measured by the square foot (square meter). Temporary panel sign supports, when required, will be measured by the linear foot (meter), complete and in place.

Type III-A, type III-B, and permanent type III barricades will be measured by the linear foot (meter) of the width of closure.

Temporary traffic barrier will be measured by the linear foot (meter) per the type specified. Anchored traffic barrier will be measured by the linear foot (meter), separately from unanchored temporary concrete barrier per the type specified. End treatments used on a type 2 or type 4 temporary traffic barrier will be measured by the linear foot (meter) as part of the barrier.

Construction zone energy absorbing terminals, cz will be measured by the number of terminals placed.

Temporary crossovers type A and type B will be measured per each crossover. The refurbishing of temporary crossovers will be measured per each type of crossover refurbished. HMA mixtures for temporary crossovers will be measured by the ton (megagram) in accordance with 109.01(b). Initial resurfacing and initial patching of refurbished crossovers will be measured in accordance with 402.19. Temporary drainage pipe for temporary crossovers will be measured by the linear foot (meter). Seeding and sodding placed due to the construction and removal or refurbishing and closing of temporary crossovers, will be measured in accordance with 621.13. Removal and subsequent replacement of permanent pavement markings and snowplowable raised pavement markers will be measured in accordance with 808.12. Removal and resetting of guardrail, if required for temporary crossovers, will be measured in accordance with 601.13.

Flashing arrow signs will be measured by the number of calendar days each unit is operated.

Patroller will be measured by the number of calendar days during the phase or phases of traffic control, as shown on the plans or as otherwise directed, that require the patroller's presence. Each portion of a day will be measured as a whole day.

Temporary pavement markings will be measured by the linear foot (meter) of material actually placed. Temporary buzz strips will be measured by the linear foot (meter) for each strip, without regard to the number of passes required to attain the specified height.

If, due to a Department initiated change or an approved expedited construction schedule, it is necessary to remove temporary non-removable pavement markings, such removal will be measured in accordance with 808.12. The removal of existing pavement markings which are in conflict with temporary markings, will be measured in accordance with 808.11.

The removal and replacement of reflectors on existing snowplowable raised pavement markers will be measured in accordance with 808.12.

Compacted aggregate No. 73 used for shoulder material will be measured in accordance with 303.09. Excavation of the existing earth shoulder will not be measured for payment.

Cones and tubular markers will not be measured for payment. Permanent tubular markers will be measured per each.

Temporary illumination, temporary traffic signals, and maintaining traffic will not be measured for payment.

801.18 Basis of Payment

The accepted quantities of construction signs, detour route marker assemblies, detour route marker assemblies-multiple routes, temporary worksite speed limit sign assemblies, road closure sign assemblies, and temporary raised pavement markers will be paid for at the contract unit price per each. Payment for temporary worksite speed limit assemblies and temporary changeable message signs will be made for the maximum number of such assemblies in place at any one time during the life of the contract. Type III-A, type III-B, and permanent type III barricades will be paid for at the contract unit price per linear foot (meter).

Temporary traffic barrier and anchored temporary traffic barrier will be paid for at the contract unit price per linear foot (meter) per the type specified. Payment will be made only once, regardless of the number of times the barrier is moved to accommodate different phases of traffic maintenance or construction operations as shown in the contract. End treatments used on a type 2 or type 4 temporary traffic barrier will be paid for on a linear basis as part of the barrier.

Construction zone energy absorbing terminal, cz will be paid for at the contract unit price per each for energy absorbing terminal, cz, of the test level placed. Each unit will be paid for only once regardless of how many times it is moved. Back-up units will be paid for as energy absorbing terminal, cz, of the test level placed, if they are placed in service due to non-repairable damage to the units already in service. Due to the nature of the TRACC-350 unit, the Engineer must agree that the in-service unit has been damaged to the extent that it is non-repairable before a standby TRACC-350 unit will be considered for payment.

The accepted quantities of temporary crossovers will be paid for at the contract unit price per each for the type specified. The accepted quantities of refurbishing existing temporary crossovers will be paid for at the contract unit price per each for the type specified. The accepted quantities of HMA for temporary crossovers will be paid for as HMA for temporary pavement at the contract unit price per ton (megagram) in accordance with 402.20. Temporary drainage pipe for temporary crossovers will be paid for at the contract unit price per linear foot (meter). Sodding and seeding for temporary crossovers will be paid for in accordance with 621.14. Removal and subsequent replacement of permanent pavement markings and snowplowable raised pavement markers will be paid for in accordance with 808.13. Removal and resetting of guardrail, if required for temporary crossovers, will be paid for in accordance with 601.14.

If more than one construction sign is mounted on a common support with the messages facing opposite directions, the largest sign will be paid for at the contract unit price of the sign, and each additional sign will be paid for at one half the unit price of the sign if it had been erected independently.

Temporary panel signs will be paid for at the contract unit price per square foot (square meter) as shown on the plans. Temporary panel sign supports will be paid for at the contract unit price per linear foot (meter), complete and in place.

Flashing arrow signs and patrollers will be paid for at the contract unit price per day per each.

Temporary pavement markings and temporary buzz strips, will be paid for at the contract unit price per linear foot (meter) of material, complete in place, except as set out below.

Permanent tubular markers will be paid for at the contract unit price per each.

The removal of temporary non-removable pavement markings caused by a Department initiated change or an approved expedited construction schedule, and the removal of existing pavement markings which are in conflict with temporary markings will be paid for in accordance with 808.13.

Compacted aggregate used for shoulder material will be paid for as compacted aggregate No. 73 in accordance with 303.10.

The removal and replacement of reflectors on existing snowplowable raised pavement markers will be paid for in accordance with 808.13.

Temporary illumination will be paid for at the contract lump sum price.

All traffic control devices and construction materials which are specified as separate pay items and used for maintenance of traffic will be paid for as set out in the Schedule of Pay Items.

The furnishing, placing, moving, removal, and maintenance of all other traffic control devices will be paid for at the contract lump sum price for maintaining traffic.

The accepted temporary traffic signal, complete in place and later removed as specified, will be paid for at the contract lump sum price.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Barricade, _____ type	LFT (m)
Barricade, III, Permanent	LFT (m)
Barrier, Direction Indicator	EACH
Construction Sign, _____ type	EACH
Detour Route Marker Assembly	EACH
Detour Route Marker Assembly, Multiple Routes	EACH
Drum, Permanent	EACH
Energy Absorbing Terminal, CZ, TL - _____ test level	EACH
Flashing Arrow Sign	DAY
Maintaining Traffic	LS
Patroller	DAY
Road Closure Sign Assembly	EACH

Road Closure Sign Assembly, Permanent .....EACH
Temporary Buzz Strips .....LFT (m)
Temporary Traffic Barrier, _____.....LFT (m)
type
Temporary Traffic Barrier, Anchored, _____.....LFT (m)
type
Temporary Crossover, _____.....EACH
type
Temporary Crossover, _____, Refurbish.....EACH
type
Temporary Crossover Drainage Pipe.....LFT (m)
Temporary Changeable Message Sign.....EACH
Temporary Illumination .....LS
Temporary Panel Signs .....SFT (m2)
Temporary Panel Sign Supports.....LFT (m)
Temporary Pavement Marking, _____ in. (mm) .....LFT (m)
width
Temporary Pavement Marking, Removable, _____ in. (mm) .....LFT (m)
width
Temporary Pavement Message Marking, _____ .....EACH
description
Temporary Pavement Message Marking, Removable, _____ .....EACH
description
Temporary Raised Pavement Marker, _____.....EACH
grade
Temporary Traffic Signal.....LS
Temporary Traffic Signal with Detectors .....LS
Temporary Transverse Pavement Marking, _____ in. (mm).....LFT (m)
width
Temporary Transverse Pavement Marking,
Removable, _____ in. (mm) .....LFT (m)
width
Temporary Worksite Speed Limit Sign Assembly .....EACH
Tubular Marker, Permanent .....EACH

The cost of delineation of temporary traffic barrier shall be included in the cost of temporary traffic barrier.

Damage done to pavement by removal of temporary traffic barriers and anchors shall be repaired with no additional payment.

The cost of all materials, equipment, labor, and incidentals necessary to install, maintain, repair, and to remove the unit shall be included in the cost of energy absorbing terminal, cz. The cost of stockpiling standby terminals and terminal materials, whether incorporated into the work or not, shall be included in the cost of energy absorbing terminal, cz. All units shall remain the property of the Contractor upon completion of the contract.

The cost of the excavation required for placement of compacted aggregate shoulders No. 73 will be included in the pay item maintaining traffic.

The cost of installation, maintenance, and removal or closure of the temporary crossover, including excavation, compaction, subgrade preparation, and reshaping damaged median area shall be included in the cost of temporary crossover.

The cost of removal of earth cover, removal of drums, reshaping damaged median areas, and closure or removal of temporary crossover shall be included in the cost of temporary crossover, refurbish.

The cost of furnishing, installing, maintaining, and subsequent removal shall be included in the cost of temporary raised pavement marker.

The cost of cleaning existing pavement and removal of buzz strips shall be included in the cost of buzz strips. Damage to the pavement caused by removal of buzz strips and temporary pavement markings shall be repaired as directed with no additional payment.

No payment will be made for temporary pavement markings which are in the standard pavement marking pattern, and which are to be in service from December 1 through the following March 31 due to the Contractor's failure to complete the work as scheduled. However, payment will be made for these markings should the failure to complete the work as scheduled be due to conditions beyond the Contractor's control.

The cost of the second application of temporary painted lines on new HMA courses shall be included in the cost of temporary pavement markings.

The cost of furnishing, installing, maintaining, and subsequent removal of the detour marker, route marker, or street or road name sign, cardinal directional marker, directional arrow marker, posts which support the assembly, and all necessary hardware shall be included in the cost of detour route marker assembly or detour route marker assembly, multiple routes.

The cost of installing, maintaining, and subsequent removal of signs, construction warning lights, assembly supports, and all necessary hardware shall be included in the cost of road closure sign assembly.

The cost of furnishing all materials, erection, maintenance, removal, and necessary incidentals shall be included in the cost of barricades.

Each construction sign, barricade, temporary worksite speed limit sign assembly, temporary changeable message sign, or flashing arrow sign will be paid for only once regardless of how many times each is moved, replaced, or how many times each is altered to change the sign message. Payment will not be made for signs or barricades used for the convenience of the Contractor.

If a temporary worksite speed limit sign assembly is not flashing when required beginning 2 h after work begins, or if such assembly is flashing when no work has been

taking place for 2 h or longer, $200.00 will be deducted from payment for such work for each 4 h period or part thereof, beginning after the 2 h grace period.

If the Contractor elects to use more than two simultaneous operations during the installation of snowplowable pavement markers or reflectors, the cost of required traffic protection devices for additional operations shall be included in the cost of maintaining traffic.

The cost of necessary flaggers; protection of traffic at structure foundations; and furnishing, erecting, placing, maintaining, relocating, and removing lights, cones, flexible channelizers, tubular markers, drums, delineators, temporary pavement markings, or other devices as directed shall be included in the cost of maintaining traffic.

Temporary mounted construction signs will not be paid for.

Replacement of snowplowable raised pavement marker castings damaged due to removing reflectors will not be paid for.

The cost of furnishing and placing cones or tubular markers in accordance with 801.08 and drums in accordance with 801.09, the watcher in accordance with 107.12, repair or replacement of damaged or inoperative traffic control devices, and traffic maintenance in accordance with 108.03 shall be included in the cost of maintaining traffic.

If the compacted aggregate No. 73 required for shoulders is removed, the cost of such removal shall be included in the cost of the compacted aggregate.

Electric energy necessary to power luminaires and temporary traffic signals will not be paid for.

SECTION 802 – SIGNS

802.01 Description

This work shall consist of furnishing the material for and erecting traffic signs in accordance with 105.03. Signs shall be installed as required unless written approval is obtained from the District Traffic Engineer to make modifications at specific locations.

Signs shall be stored in such a manner that they do not come in contact with surface run-off water. Signs shall be stored so that moisture accumulation or heat build-up does not occur.

All signs shall be marked for identification as shown on the plans. The marking shall consist of a type II sheeting material, with a class I adhesive, shown on the Department's list of approved Sign Sheeting Materials. It shall be applied to the back of the sign on the lower corner closest to the nearest edge of pavement and shall not be covered by the sign's supports.

MATERIALS

802.02 Materials

Materials shall be in accordance with the following:

Concrete	702 or 901.08
Fasteners	919.01(d)
Overhead Sign Structure	910.19
Reinforcing Steel	910.01
Sign Posts	910.14
Traffic Signs	919.01

Materials used for temporary construction signs, temporary traffic signs, and temporary panel signs shall meet the requirements herein. The basis for use of the materials will be by visual inspection with no additional testing, evaluation, or documentation.

CONSTRUCTION REQUIREMENTS

802.03 Location of Signs and Sign Structures

Sign and sign structure locations shall be staked, and the Engineer will either approve the locations or give written notice of necessary changes. The provisions of 109.03 will not apply to posts ordered prior to approval of staked locations.

Two days notice shall be provided for inspection and approval of staked locations.

All signs shall be adjusted to eliminate specular reflection.

802.04 Shop Drawings

Prior to fabrication, six sets of shop drawings in accordance with 711.05 shall be submitted for all strain poles and structural frames, except breakaway posts. Roadway cross sections and bridge dimensions shall be checked, as applicable, in the field prior to preparation of shop drawings. Notice of all discrepancies shall be provided to the Engineer so necessary design revisions can be made prior to preparation of the shop drawings. If the no-load camber is not shown on the plans, the Contractor shall furnish this camber in the shop drawings.

802.05 Excavation and Backfill

The finished pavement or shoulder section shall not be damaged during excavation.

The Engineer shall be notified in writing of class X material in accordance with 206.02 encountered within the limits of the traffic sign supports foundation excavation. The Engineer will determine the design for the installation of the foundations. Excavation of class X material shall be in accordance with 206.

The excavation for sign posts shall be made as nearly as possible to neat lines. Sign post encasement shall not be formed except in sandy soil, or as directed.

802.06 Placing Concrete

Placing concrete shall be in accordance with 702, except that foundations incorporated into sections of concrete barrier wall shall receive a finish in accordance with 702.21. Exposed concrete shall have a smooth surface and beveled edges.

802.07 Installing Supports

(a) Posts

Posts shall be vertical after installation. All damaged posts shall be removed and replaced with an acceptable post.

Square sign post foundations shall be reinforced anchor base or unreinforced anchor base as shown on the plans. If sign post type A or sign post type B is specified, square sign posts may be used. Splicing of square steel sign posts will not be permitted.

In locations where class X excavation is encountered, the Engineer will determine the design for the installation of foundations. If the total length of the anchor bolts cannot be used, they shall be cut off. A steel plate measuring 6 by 6 by 1/2 in. (150 by 150 by 13 mm), shall be welded to the bottom of the bolts. The plate shall have a hole cut which allows the bolt to pass through it and the plate and bolt shall be completely welded together around the circumference of the bolt on both sides of the plate. No butt welding is allowed. The length of the bolts shall allow the plate to be covered by 3 to 4 in. (75 to 100 mm) of concrete at the bottom of the foundation.

(b) Structural Frames

When erection of the structure has been started, it shall be completed the same day. The structure shall be loaded, to prevent vibration, by attaching signs or lighting supports the same day.

An oxidation inhibitor in accordance with 802.07(b)4 shall be applied to all surfaces that mate with a dissimilar material.

Fasteners shall be tightened by turn-of-nut tightening, calibrated wrench tightening, or direct tension indicator tightening. The calibrated wrench shall be calibrated by an acceptable tension measuring device such as a Skidmore-Wilhelm.

The base plate bolt tightening shall be as follows:

a. Lower nuts and washers shall be in full contact with the base plate,

b. The top nuts shall be tightened to one-sixth turn beyond snug fit,

c. The lower nuts shall be retightened to assure that full contact with the base plate has been maintained.

Damage that is detrimental to the structural integrity of the frame or aesthetic appearance shall be repaired.

Field welding of aluminum shall be in accordance with 803. Field welding of steel shall be in accordance with 711.32.

The grounding connection shall be located 12 in. (300 mm) from the bottom of the support and shall be easily accessible from the structure manhole.

Traffic shall be maintained in accordance with 801.16 during installation.

1. Trusses

When placed on blocks to produce the required camber, the truss sections shall fit together at the flange connections with a minimum gap of 1/16 in. (1.5 mm) on any flange assembly. The total of the gaps in any one connection shall not exceed 1/8 in. (3 mm). Gaps shall be shimmed with tapered shims before tightening the flange bolts.

All signs and walkway brackets shall be placed as close to the brace points as possible. The Contractor shall verify that the dimensions are suitable for the type of fixture to be supplied.

2. Monotube

The required camber shall be achieved in accordance with the manufacturer's recommendation as detailed on the shop drawings.

3. Cantilever Arms

Cantilever arms shall fit together at the flange connections between sections with a minimum gap of 1/16 in. (1.5 mm) on any flange assembly. The total of the gaps in any one connection shall not exceed 1/8 in. (3 mm).

4. Bridge Brackets

The location of the sign bracket may be shifted to avoid joints or stiffeners on the bridge. Before placing aluminum in contact with concrete, both the concrete and aluminum surfaces shall be coated with an aluminum-impregnated caulking compound. Where aluminum surfaces are to be placed in contact with steel, the steel surface shall be given one coat of zinc chromate paint and the aluminum surfaces shall be coated with an aluminum-impregnated caulking compound before placement. After the bolts have been tightened, the excess caulking compound shall be removed. All openings around the flanges shall be fully painted and shall be flush with the caulking compound.

802.08 Installing Signs

If new signs are to be installed on existing structural frames, the existing mounting hardware, if applicable, may be reused. Bolts, nuts, and washers shall not be reused. Additional new hardware may be required to complete the mounting. All such sign hangers protruding above the new signs shall be cut off flush to the top of the signs. Splicing or overlapping of sign hangers will not be permitted. All unused sign hangers and hardware shall be removed.

A minimum of two sign support bracket assemblies will be required for all signs having a width greater than 30 in. (750 mm). Signs 7ft (2.1 m) or less in height shall have sign support bracket assemblies mounted at a maximum spacing of 7 ft (2.1 m). Signs greater than 7 ft (2.1 m) in height shall have sign support bracket assemblies mounted at a

maximum spacing of 5 ft (1.5 m). Sign overhang beyond the end bracket assembly shall be not more than half the spacing of the bracket assemblies.

(a) Sheet Signs

Sheet signs shall be fastened to the post as shown on the plans. Rivets shall be used to fasten sheet signs mounted to panel or other sheet signs. Steel and plastic washers shall be placed as shown on the plans. Lock-nuts shall be tightened sufficiently so that the sign is held firmly against the post. If the sign sheeting is twisted or damaged, the sign shall be replaced.

Lock-nuts for cable span mounted signs shall be tightened so that the sign is held firmly against the cable. There shall be no deformation or twisting of aluminum sheeting, or damage to the reflective sheeting.

(b) Panel Signs

Panel signs shall be mounted as follows:

1. Up to and including 24 ft (7300 mm) of sign width, clips shall be placed on both sides of each post at the top and bottom of the sign. Intermediate clips shall be placed one on each panel on each post and shall alternate left and right on each post.

2. Over 24 ft (7300 mm) of sign width, double clips shall be used, one on the right side and one on the left side on each post per panel width, plus the sets necessary to attach the top and bottom of the sign.

3. Lock-nuts shall be torqued two full turns beyond snug fit.

Panels shall be bolted together on 24 in. (600 mm) centers with an allowable gap of no more than 1/16 in. (2 mm) between units. Panels shall be temporarily braced in accordance with the panel manufacturer's recommendations.

802.09 Removal or Relocation of Signs or Support Assemblies

Signs to be relocated shall be installed in accordance with the MUTCD and on new posts.

Signs or support assemblies to be removed shall be removed within five work days after the required replacement signs or support assemblies are installed. Concrete foundations shall be removed to a minimum depth of 1 ft (0.3 m) below the ground surface. After concrete foundations have been removed, the area shall be backfilled and seeded or sodded in accordance with 621, or treated with a material which matches that in the surrounding area.

802.10 Roadway and Bridge Reference Signs

If existing roadway and bridge reference signs interfere with the prosecution of other work, such signs and posts shall be removed, stored, and then reinstalled within 25 ft (7.5 m) of their original longitudinal location or as directed.

802.11 Method of Measurement

Sheet signs and panel signs will be measured by the square foot (square meter). Sheet signs will be measured as the smallest dimensions of a square or rectangle large enough to make the sign. However, triangular or trapezoidal signs will be measured as the smallest triangle or trapezoid required to make the sign.

If the pay unit for sheet signs is shown in the Schedule of Pay Items as each, the number of sheet signs specified, including posts, hardware, and erection, will be measured by the number of units installed.

Sign posts will be measured by the linear foot (meter). Square sign posts will be measured from the top of the post to the termination of the post in the anchor base.

Traffic sign support foundations will be measured by the number of units of each type installed. No reduction will be made in a unit if class X material is encountered during foundation excavation.

If class X material is encountered during foundation excavation, the quantity to be measured will be that authorized and removed and in accordance with 206.10.

Structural steel, breakaway, will be measured by the pound (kilogram). Such measurement will include the weight (mass) of breakaway sections such as stubs, stiffeners, base plates, and fuse plates. For rigid sections, the weight (mass) of the base plate will be included.

Reference posts, including post, sign, and hardware, will be measured by the number of units installed.

Backfill of traffic sign support foundations will be measured in accordance with 211.09.

Overhead sign structures and bridge bracket assemblies will be measured by the number of units of each type installed.

Overhead sign structures to be removed will be measured by the number of structures removed.

802.12 Basis of Payment

The accepted quantities of sheet signs and panel signs will be paid for at the contract unit price per square feet (square meter), of the type and thickness specified, with legend, complete in place.

Sign post will be paid for at the contract unit price per linear foot (meter) for the type specified.

Structural steel, breakaway, will be paid for at the contract unit price per pound (kilogram).

Ground mounted sign support foundations will be paid for at the contract unit price per each type specified.

Reference posts will be paid for at the contract unit price per each, complete in place.

Payment for class X material encountered during a foundation excavation will be made in accordance with 206.11.

Payment for backfill of support foundations will be made in accordance with 211.10.

The removal of signs, overhead structures, and sign assemblies, will be paid for at the contract unit price per each.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Box Truss Sign Structure Foundation, _____ (type)	EACH
Bridge Bracket Assembly	EACH
Cable Span Sign Structure Foundation, _____ (type)	EACH
Cantilever Sign Support Foundation, _____ (type)	EACH
Overhead Balanced Cantilever Sign Structure Foundation, _____ (type)	EACH
Overhead Sign Structure, _____ (type)	EACH
Overhead Sign Structure, _____, Remove (type)	EACH
Reference Post	EACH
Sign and Supports, Wide Flange, Remove	EACH
Sign Post, _____ (type)	LFT (m)
Sign Post, Square, _____, Reinforced Anchor Base (type)	LFT (m)
Sign Post, Square, _____, Unreinforced Anchor Base (type)	LFT (m)
Sign, Double Faced, Sheet, _____, With Legend, _____ (type, thickness)	SFT (m2)
Sign, Overhead, Remove	EACH
Sign, Panel, With Legend	SFT (m2)
Sign, Panel, Relocate	EACH
Sign, Panel, Remove	EACH
Sign, Sheet Assembly, Rotate	EACH
Sign, Sheet, _____, With Legend, _____ (type, thickness)	SFT (m2)

Sign, Sheet, and Supports, Remove .....EACH
Sign, Sheet, Relocate.....EACH
Sign, Sheet, Remove .....EACH
Sign, Sheet, With Legend.....EACH
Structural Steel, Breakaway .....LBS (kg)
Wide Flange Sign Post Support Foundation, _____ .....EACH
type

The cost of staking sign and sign structure locations, including materials and labor, shall be included in the cost of the pay items in this section.

The cost of all hardware necessary to assemble and attach the sign to its structural supports, all legend, and adjustments necessary to eliminate specular reflection shall be included in the cost of sheet sign or panel sign.

The cost of all hardware to attach the sign to its structural supports, the reflective sheeting on both faces, and all legend shall be included in the cost of double-faced sheet signs.

The cost of all necessary hardware including sign hangers, clips, and U bolts required for the mounting of signs to existing or new overhead sign structures shall be included in the cost of the sign.

The cost of modifying existing hardware to mount a new sign shall be included in the cost of the new sign.

The cost of the reinforced anchor base or unreinforced anchor base, angle bolts, and rivets shall be included in the cost of sign post, square.

The cost of identification markings for signs shall be included in the cost of the sign.

The cost of sign removal, existing post removal, and all mounting hardware necessary to attach the existing sign to new posts, shall be included in the cost of the sign relocation.

The cost of roadway and bridge reference signs and posts to be removed, stored, and reinstalled shall be included in the cost of other pay items, unless otherwise specified. Roadway and bridge reference signs which are damaged by the Contractor shall be replaced with no additional payment.

The cost of furnishing and applying aluminum-impregnated caulking compound and zinc chromate paint as required in 802.07, shall be included in the cost of the pay items in this section.

The cost of removal of signs, sign assemblies, sign lighting circuitry, supports, concrete foundations, backfill material, sodding, seeding, and necessary incidentals shall be included in the cost of overhead sign structure, remove.

The replacement of posts damaged by the Contractor's activities shall be without additional payment.

The cost of concrete, reinforcement, stub, anchor bolts, conduit, and all necessary hardware shall be included in the cost of the support foundation.

The cost of cutting the reinforcing steel and anchor bolts, furnishing the steel plate and welding the plate to the ends of the anchor bolts when class X excavation is encountered shall be included in the cost of the pay items in this section.

No additional payment will be made if square sign posts are used in lieu of type A or type B posts.

The cost of excavation, except for class X material, and necessary incidentals shall be included in the cost of the pay items in this section.

SECTION 803 – WELDING ALUMINUM ALLOYS

803.01 Description

This work shall consist of welding aluminum alloys for highway structures. The welding terms used shall be in accordance with definitions included in the AWS Definitions "MD" Welding and Cutting, AWS A3.0. The welding symbols to be used on shop drawings shall be those shown in the Standard Welding Symbols, AWS A2.0. Special conditions shall be fully explained by added notes or details.

The aluminum alloys to be welded under these specifications may be any of the following ASTM alloy designations:

1. wrought non-heat-treatable alloys 3003, 3004, 5052, 5083, 5086, 5456;

2. wrought heat-treatable alloys 6061, 6063; or

3. cast heat-treatable alloy 356.0

803.02 Materials

Materials shall be in accordance with the following:

Electrodes.....924.01
Filler Material.....924.01
Shielding Gases.....924.01
Welding Rods.....924.01

Material used for permanent backing shall be at least equivalent in weldability to the base metal being welded.

803.03 Welding Processes

The welding process shall be by the gas metal-arc process or the gas tungsten-arc process. Other processes may be used if prior approval is given.

(a) Preparation of Materials

Joint details shall be in accordance with design requirements and detail drawings. The location of joints shall not be changed without approval.

Edge preparation shall be by sawing, machining, clipping, or shearing. Gas tungsten-arc or gas metal-arc cutting may also be used. Cut surfaces shall meet the ANSI surface roughness rating value of 1000. Oxygen cutting shall not be used.

Surfaces and edges to be welded shall be free from fins, tears, and other defects which would adversely affect the quality of the weld. Dirt, grease, forming or machining lubricants, and organic materials shall be removed from the areas to be welded by cleaning with a suitable solvent or by vapor degreasing.

The oxide shall be removed from all edges and surfaces to be welded by wire brushing or by other mechanical methods such as rubbing with steel wool or abrasive cloth, scraping, filing, rotary planing, or sanding just prior to welding. If wire brushing is used, the brushes shall be made of stainless steel. Hand or power driven wire brushes which have been used on other materials shall not be used. Where mechanical methods of oxide removal are found to be inadequate, a standard chemical method shall be used. Welding shall be done within 24 h after chemical treatment. When gas tungsten-arc welding with direct current straight-polarity is being used, all edges and surfaces to be welded shall have the oxide removed by a standard chemical method.

Welding shall not be done on anodically treated aluminum unless the condition is removed from the joint area to be welded.

(b) Welding Procedure

All butt welds requiring 100% penetration, except those produced with the aid of backing, shall have the root of the initial weld chipped or machined out to sound metal before welding is started from the second side. Butt welds made with the use of backing shall have the weld metal fused with the backing. Where accessible, backing for welds that are subject to computed stress or which are exposed to view on the completed structure and which are not otherwise parts of the structure, shall be removed and the joints ground or machined smooth. In tubular members, butt welds subjected to computed stresses shall be made with the aid of permanent backing rings or strips.

The procedure used for production welding of any particular joint shall be the same as used in the procedure qualification for that joint.

All welding operations, either shop or field, shall be protected from air currents or drafts so as to prevent any loss of gas shielding during welding. Adequate gas shielding shall be provided to protect the molten metal during solidification. The work shall be positioned for flat position welding whenever practicable. All weld joints shall be dry at the time of welding.

The size of the electrode, voltage and amperage, welding speed, gas or gas mixture, and gas flow rate shall be suitable for the thickness of the material, design of joint, welding position, and other circumstances attending the work. Gas metal-arc

welding shall be done with direct current, reverse polarity. Gas tungsten-arc welding shall be done with alternating current or with direct current, straight polarity.

When the joint to be welded requires specific root penetration, the Contractor shall make a sample joint and a macro etched cross section of the weld to demonstrate that the joint welding procedure to be used is attaining the required root penetration. The sample joint shall have a length of at least 1 ft (0.3 m) and shall be welded with the electrode, polarity, amperage, voltage, speed, gas mixture, and gas flow rate that are proposed to be used in production welding. Evidence on record may be accepted in lieu of the receding test.

Where preheat is needed, the temperature of preheat shall not exceed 350°F (177°C) for heat-treated alloys and 600°F (316°C) for non-heat-treated alloys. The temperature shall be measured by temperature indicating crayons or by pyrometric equipment. Heat-treated alloys shall not be held at the maximum preheat temperature or at temperatures near the maximum for more than 30 min.

(c) Weld Quality

Welds will not be accepted if they contain cracks in the welds or in the adjacent base metal, copper inclusions, or porosity in excess of that permitted by Appendix IV, Section VIII, of the ASME Boiler and Pressure Vessel Code.

Lack of fusion, incomplete penetration, or tungsten or oxide inclusions will be acceptable only if small and well dispersed.

Undercut shall be no more than 0.01 in. (0.3 mm) deep when its direction is transverse to the primary stress in the part that is undercut. Undercut shall be no more than 1/32 in. (0.8 mm) deep when its direction is parallel to the primary stress in the part that is undercut. Overlap shall not be allowed. All craters shall be filled to the full cross section of the welds. Welds having defects greater than the levels of acceptance specified herein shall be considered as rejected unless corrected in accordance with 803.03(e).

(d) Inspection

All welds shall be inspected visually to determine compliance with 803.03(c). In addition, all welds subjected to computed stress shall be inspected by the dye penetrant method except as specified below. For highway sign structures, the dye penetrant method shall be used on butt welds in columns and main chord members; on fillet welds connecting columns to bases and main chord members, including the associated flanges, gussets, or main load carrying brackets or members; and on fillet welds connecting flanges to the main truss chord members. The dye penetrant tests shall be performed in accordance with ASTM E 165, method B, procedures B-2 or B-3. Dye penetrant inspection may be omitted provided that the inspector examines each layer of weld metal with a magnifier of 3X minimum before the next successive layer is deposited.

(e) Corrections

In lieu of rejection of an entire piece or member containing welding which is unacceptable, the corrective measures listed below may be permitted if approval is obtained prior to making each repair. Defective welds shall be corrected by removing and replacing the entire weld, or as follows:

1. Cracks in Welds or Base Metal

Determine the full extent of cracks by dye penetrant method or other positive means. Remove the cracks throughout their length and depth, and reweld.

2. Excessive Porosity and Lack of Fusion

All defective portions are to be removed and rewelded.

3. Copper or Tungsten Inclusions

All defective portions are to be removed and rewelded.

4. Excessive Concavity of Crater, Undercut and Undersize Weld

The weld shall be cleaned and additional weld metal shall be deposited.

5. Overlap

Overlap shall be reduced by removal of the excess weld metal.

The defective areas shall be removed by chipping or machining. Oxygen cutting shall not be used. Before rewelding, the joint shall be inspected to ensure all the defective weld has been removed. If dye penetrant has been used to inspect the weld, all traces of penetrant solutions shall be removed with solvent, water, heat, or other suitable means before rewelding.

803.04 Qualification of Procedures, Welders, and Welding Operators

Joint welding procedures shall be qualified previously by tests prescribed in Part B, Section IX, of the ASME Boiler and Pressure Vessel Code. Evidence of previous qualification of the joint welding procedures to be employed may be accepted.

All welders and welding operators shall be previously qualified by tests in accordance with Part B, Section IX, of the ASME Boiler and Pressure Vessel Code. Evidence of previous qualification of the welders and welding operators to be employed may be accepted. The same process and type of equipment that is required for execution of the contract work shall be used in qualifying welders and welding operators.

SECTION 804 – DELINEATORS

804.01 Description

This work shall consist of furnishing and erecting delineators in accordance with 105.03 and 107.12. Delineators shall be installed as required unless approval is obtained from the District Traffic Engineer to make modifications.

MATERIALS

804.02. Materials

Materials shall be in accordance with the following:

Delineator Posts 910.15
Flexible Delineator Posts 926.01
Delineators 926.02

The types of delineators shall be:

(a) D1 – single;

(b) D2 – double;

(c) D3 – triple.

Hardware for mounting delineators on posts shall be aluminum alloy in accordance with 919.01(d)2; stainless steel or galvanized steel in accordance with 919.01(d)1; or aluminum pull-through blind rivets. Bolts and lock-nuts or rivets shall be 3/16 in. (4.8 mm) diameter.

CONSTRUCTION REQUIREMENTS

804.03 Delineator Visibility

Delineator reflector units shall be positioned so as to be visible for a distance of 1000 ft (300 m) on tangent sections or at maximum visibility distances on curves. These locations shall be established under normal weather and atmospheric conditions when illuminated by the upper beam of standard automobile headlights.

804.04 Posts

Posts shall be installed in accordance with 802.07.

804.05 Flexible Delineator Posts

These posts shall be installed according to the manufacturer's recommendations and shall be set so that the top is no more than 1/2 in. (13 mm) from any vertical plane through the bottom.

804.06 Method of Measurement

Delineators with posts, delineator posts, and flexible delineator posts will be measured by the number of units of the type specified.

804.07 Basis of Payment

The accepted quantities of delineators, delineators with post, delineator post, and flexible delineator post, if set out as a separate pay item, will be paid for at the contract unit price per each for the type specified, complete in place.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Delineator	EACH
Delineator Post	EACH
Delineator Post, Flexible	EACH
Delineator with Post, _____ (type)	EACH

Where new delineator posts are installed to replace existing delineator posts, the cost of the removal of the existing post shall be included in the cost of the new post.

SECTION 805 – TRAFFIC SIGNALS

805.01 Description

This work shall consist of furnishing miscellaneous materials, not furnished by the Department, and installing traffic signals in accordance with these specifications and in reasonably close conformance with the lines, grades, and locations shown on the plans or as directed.

MATERIALS

805.02 Materials

Materials shall be in accordance with the following:

Castings for Handhole.....910.05(b)
Coarse Aggregate, Class E or Higher, Size No. 8.....904
Concrete, Class A, B, or C.....702
Reinforced Concrete Pipe 907.02
Traffic Signal Materials and Equipment.....922
Treated Lumber.....911.02

The proposed work shall be examined in order to determine what materials not furnished by the Department are required to complete the contract. The Department will furnish only the materials specified on the Department Furnished Materials special provision. If materials to be furnished by the Contractor are listed, the list is only a guide for estimating purposes. All additional materials required to complete an operating installation as specified shall be furnished.

Signal handholes shall be class III reinforced concrete pipe as shown on the plans.

Wood poles to be furnished shall be in accordance with the current ANSI specifications and dimensions. They shall be of the length and class specified, be fully treated in accordance with 922.05(b), and dry. Minimum circumference at the top and at a point 6 ft (1.8 m) from the butt shall be in accordance with ANSI specifications.

Steel strain poles greater than 24 ft (7.3 m) in length shall be in accordance with 922.05(a).

CONSTRUCTION REQUIREMENTS

805.03 General Requirements

The Contractor shall maintain existing traffic signals in operation until the Engineer determines that the progress of the work necessitates their removal. The new installation shall not interfere with the operation of the existing signal. The work shall proceed in such a manner that the signals are not out of service at any two adjacent intersections at any time. When the operation of an existing traffic signal must be interrupted before the new signal is placed in operation, the traffic shall be controlled at

all times. The work shall be scheduled so that the interruption is limited to a minimum amount of time and at off peak hours. When a new span, catenary, and tether are to be installed on an existing structure, the work shall be done so as not to damage the structure. Tether cable will not be required on a flasher installation. If an existing structure is damaged, it shall be repaired or replaced as directed with no additional payment. The new span and catenary installation shall not interfere with the operation of the existing traffic signal. Traffic shall be controlled at all times during the changeover when the existing traffic signal is turned off and the new signal is turned on. This changeover shall take place such that the interruption is limited to a minimum amount of time.

When directed, temporary stop signs shall be erected at the intersection. When no work is in progress, the intersection shall have at least two operating signal faces for each approach. When the new installations are completed, any existing signal equipment and materials including wood poles, steel poles, and cast-iron handhole rings and covers which have not been used in the new installation shall be carefully removed. Regardless of the right to materials found on the project, as set out in other sections of these specifications, these items shall be stored at a secure site and salvaged by the appropriate governmental agency. The Contractor shall be responsible for any damage or loss of this equipment and shall repair or replace the same with no additional payment.

All existing painted signal equipment to be reused, such as pedestals, bases, controller cabinets, signal heads, signal weatherheads, pipe arms, shall be cleaned and painted with two coats of highway yellow enamel. Aluminum poles and mast arms shall not be painted.

Existing concrete foundations, which have not been used in the new installation, shall be removed to a minimum of 4 in. (100 mm) below the adjacent grade. The openings shall be filled with concrete and the surface finished and broomed, if they are located in sidewalk areas. Otherwise, they shall be filled with acceptable material conforming with the surrounding area. Existing signal handholes to be removed, shall be filled after removing rings and covers, with B borrow with a minimum of 4 in. (100 mm) of concrete on top to bring it up to grade in a sidewalk area. Surfaces shall be finished and broomed. Otherwise, they shall be filled with acceptable material conforming with the surrounding area.

The signal controller timings will be provided and the Engineer shall be present when the signal intersection is to be placed in operation.

All electrical wiring terminations and splices; controller and cabinet set-up; and testing, review, and turn-on of all operational apparatus at each location shall be done by or in the presence of and under the responsible charge of an employee of the Contractor who holds a Level II Traffic Signal Electrician certification which has been granted by the International Municipal Signal Association. Supervision of non-electrical, traffic signal related construction work and traffic control shall be done by a person holding a Level I Work Zone Traffic Safety Specialist certification which has been granted by the International Municipal Signal Association, or an equivalent certification approved by the Department.

Before starting work, the Contractor shall provide the names of the Level II Traffic Signal Electricians and Level I Work Zone Traffic Safety Specialists who have been assigned to perform signal related work, and a photocopy of each such person's certification card. If the Level II Traffic Signal Electricians or Level I Work Zone Traffic Safety Specialists are dismissed from the work, all signal related work requiring such certified personnel on the project site shall cease until the names and photocopies of certification cards for replacement personnel are provided to the Engineer.

Electrical work shall be executed in accordance with the requirements of the National Board of Fire Underwriters, the State Fire Marshal, and the power company which will furnish the electric service. The work shall be in accordance with any local regulations that may apply. The Department will arrange and provide for power service which the power company will bring to the point designated on the plans. Prior to the start of construction, the schedule of activities shall be coordinated with the power company and they shall be contacted again at least 14 days prior to the time the service work is to be completed.

The Department will obtain permits from local officials, companies, or individuals for the use of poles, right-of-way, or other property incidental to the installation of traffic signal. Although entering into the contract implies permission and authority to cut into and push under pavement, sidewalks, and alleys, any damage to underground utilities or interruption of such service shall be the responsibility of the Contractor. The Contractor shall be in accordance with local regulations as well as 107.08. Protective devices shall be in accordance with 107.12 and 801.

The location of signal heads, controllers, signal poles, signal cantilever structures, detector housing, disconnect hangers, and other installation items will be shown on the plans. However, a change in the location of an item may be ordered during the progress of the work. The work shall be completed as shown on the plans except for those changes specifically authorized in writing.

805.04 Pole Installation

Metal poles shall be erected on concrete foundations and shall be reasonably plumb after installation of signal heads. The handhole side of the pole shall be at right angles to the direction of the mast arm or span, catenary, and tether. Signal cables shall be brought up inside the poles. Any steel pole, mast arm, or hardware not galvanized or painted with baked enamel shall be painted with two coats of rust inhibiting aluminum paint. Paint shall be applied in accordance with 619 with the exception that commercial blast cleaning of the steel will not be required. All rust, scale, and dirt shall be cleaned from the metal surface so that paint adheres to the surface.

The construction of concrete foundations shall be in accordance with 805.13. Wood poles shall be set a minimum of 7 ft (2.1 m) in the ground and raked 12 in. (300 mm).

805.05 Placing Signal Heads

Mast arm and span mounted signal heads shall have 17 ft (5.2 m) minimum and 19 ft (5.8 m) maximum clearance over the roadway unless there are visual obstructions which require lowering the signal head. A signal head over the roadway shall not have a

clearance of less than 15 ft (4.6 m). Such signal heads shall be located over the intersection as shown on the plans. Such signal heads shall have a uniform clearance, which will be determined. Signal heads not mounted over a paved roadway, on the top or side of a pole, shall not be less than 10 ft (3 m) nor more than 15 ft (4.6 m) above the sidewalk or, if none, above the pavement grade at the center of the roadway. Signal faces shall be directed to the proper approach lane in each direction. Pedestrian signal faces shall be mounted with the bottom of the housing at not less than 7 ft (2.1 m) nor more than 10 ft (3 m) above the sidewalk. The pedestrian signal shall be in line with the pedestrian's vision at the appropriate crosswalk being used. Pedestrian push-buttons shall be mounted at a height of 3 1/2 to 4 ft (1.1 to 1.2 m) above the sidewalk as shown on the plans. A pedestrian actuated signal sign shall be mounted immediately above the push-button.

Signal heads shall be assembled and wired with one conductor, THW, stranded wire. Where splices are made, a 2 ft (0.6 m) minimum length of cable or wire in excess of that required for a continuous run shall be provided. Splices shall be twisted together and soldered or approved type connectors used. Each splice shall be completely insulated by wrapping with an approved tape and sealed with an approved electrical coating material. Splices shall be made in such manner that the connections are moisture proof. The cables coming out of the signal weatherhead shall be looped to form a drip loop. The drip loop shall be made so that the cables coming out of the weatherhead loop down below the elevation of the weatherhead to prevent water from following the cable into the weatherhead. If used, the splice indicated above shall be located in the top of the coils of cable forming the drip loop.

Signal heads shall not be installed until all other work has been completed. If it becomes necessary to mount signal heads for more than 2 h before the lights are to be turned on, the signal heads shall be hooded by placing sacks or similar cover over them so as to conceal them from traffic. Hooded signal heads are not permitted to be in place for more than five days. No signal head shall be left over night with the lights out unless it is hooded. Signal heads shall be securely mounted. The polycarbonate signal face shall be used only when securely supported on both ends of the assembly. In a span cable installation, a tether cable would satisfy this requirement.

805.06 Grounding

All signal supports, signal controller supports, and entrance switches shall be grounded in accordance with the applicable requirements of 807.12.

805.07 Wire and Cable Installations

All cable runs attached to utility poles shall have code clearance relative to utility cables. They shall be no less than 18 ft (5.5 m) above the ground level except over railroad tracks when a minimum of 27 ft (8.2 m) clearance shall be maintained. All cable runs shall be installed in continuous lengths without splices between terminals except when necessary at handholes, junction boxes, pole signal bases, and pedestal bases. The type of cable and the number of conductors as well as the gage shall be as shown on plans unless otherwise specified.

Cable rings shall be used to support the signal cable on the signal span cable. They shall be spaced 12 in. (300 mm) on center. Cable shall be pulled through the

conduit to the terminal panel in the controller cabinet. Caution shall be used to prevent damage to the cable when it is being pulled through conduit.

Coded cable conductors shall be used throughout the installation. Cable conductors shall be tagged at all detector housing, handholes, pole signal bases, and controller cabinets. Tags shall consist of an aluminum blank of sufficient size to be stamped with not less than 3/16 in. (5 mm) high all upper case letters which identify the cables by their use and phase. The following are the uses which shall be indicated by the tags:

(a) Power

(b) Pedestrian Signal

(c) Pedestrian Actuation

(d) Signal-Phase Identification

(e) Detection Loop Identification

Loop identification shall consist of the following:

Inside of the Detector Housing, the loop wires of each loop shall be tagged with, in _____, out _____, as shown on the plans.
Loop Number Loop Number

Inside of the Controller Cabinet, each lead-in cable shall be tagged within 6 in. (150 mm) of the terminal strip connection with: Lane designation, Phase Number, Loop Number, and when applicable with loop system number, and speed trap according with the plans.

Phase identification shall consist of the single number “1”, “2”, “3”, etc., which corresponds to the phase diagram for the respective intersection. Tags shall be securely fastened to the cable with a non-corroding material. The tagging material and fastening shall be approved prior to proceeding with this work. The color coded wires shall be connected properly. The white wire shall be the common or ground. Wire used for all identical indications of any individual phase shall be color coded and, where possible, shall use red wire to connect red lenses, orange wire to connect yellow lenses, and green wire to connect green lenses. Signal heads shall be assembled and wired before being installed. The testing of the loops shall be documented in the Loop Testing Table provided by the State.

805.08 Controller Cabinet, Signal Service, and Detector Housing Installation

The controller cabinet shall be mounted securely on a pole, pedestal, or concrete foundation. All cabinets on concrete foundations shall be installed with the anchor bolts inside. Controller cabinets on poles or pedestals shall be mounted at a height of 38 in. ± 2 in. (970 mm ± 50 mm). Pole mounted controller cabinets shall be fastened with two stainless steel bands as shown in the plans. Signal cables and lead-in cable shall be run in conduit from the controller cabinet to the signal support base and to detector housing as

indicated on the plans. Galvanized steel elbows shall be used on the detector housing as shown on the plans.

The Contractor shall wire the entrance switch and bring service cable up the riser and out the weatherhead and leave 4 ft (1.2 m) of cable outside the weatherhead. The utility company, at their option, may bring the service cables to the load side of the entrance switch. Meter bases, if required, shall be obtained from the power company and any service connection or miscellaneous charges shall be assumed by the Contractor.

A minimum of 12 in. (300 mm) and a maximum of 18 in. (450 mm) of loop wire duct will be permitted in the detector housing for each loop lead. Concrete used in the installation of detector housings shall be in accordance with 506, except where a portion of the road is closed or where there is no vehicular traffic, then class A concrete in accordance with 702 may be used. The concrete shall be placed flush with existing surface and shall be covered with a steel plate during the setting time.

805.09 Loop Wire Detector Installation

This work shall consist of placement and testing of loop wire detectors in accordance with the installation details shown on the plans.

MATERIALS

Loop wire shall be in accordance with 922.06(e)7b. Loop detector sealant shall be in accordance with 922.06(e)7c.

Loops shall be of a regular octagon shape with side of 2.5 ft (0.75 m) in length. An outline shall be laid out and painted where the loops shall be sawed. The loop locations shall be subject to the review and approval of the District Traffic Engineer. The District Traffic Engineer shall be notified 48 h prior to such field review.

The slots shall be saw-cut as shown on the plans. Slots shall be thoroughly cleaned and dried before the installation of loop wires. The specified number of turns shall be placed in the slot and gently tamped with a blunt non-metallic tool. A sash cord or backer rod shall be placed above the wire after tamping. The number, size, arrangement, and locations of loops shall be as shown on the plans. Loop spacing shall be adjusted to avoid pavement joints. Loop wire shall be pressed into the saw slot with a blunt non-metallic tool. Loop wire shall only be bent at angles of 120° or greater. All loops shall be wired clockwise as viewed from above. Loops shall be wired with four turns and in a series unless otherwise specified. Joints shall be overlapped such that the saw cut at the corner is full depth. The sealant shall be poured into the saw cut making a water tight seal. The splice of the loop wire and lead-in cable shall be soldered and waterproofed at the detector housing. Waterproofing shall consist of the use of heat shrink tubing which has an internal coating sealant material. The heat shrink tubing shall not be heated by means of a direct flame tool. Loop wire and lead-in cable shall be tagged according to the plans and 805.07. The black lead-in wire shall be spliced to the loop wire which goes back to the field. Such wire shall be tagged as “Out/Loop (No.)”. The white lead-in wire shall be spliced to the loop wire which comes in from the field. Such wire shall be tagged as “In/Loop (No.)”.

TESTING

The Contractor shall meter all new loop wire detectors or a new bank of loop wire detectors by means of instruments capable of measuring electrical values for installed loop wires and lead-in cables. The instruments shall measure inductance in microhenries, resistance in ohms, induced A.C. voltage in volts, and leakage resistance in megohms. All measuring tests shall be performed at the detector housing before the loop wire is spliced to the lead-in cable, and at the cabinet after the loop wire is spliced to the lead-in cable.

(a) Megohm Test Before Splice is Made at Detector Housing for Loop Wire

One of the megohm probes shall be connected to ground and the other probe shall be connected to the "in" or "out" loop wire. The remaining loop wire shall be isolated. The test shall then be performed.

(b) Megohm Test Before Splice is Made at Detector Housing for Lead-in Cable

The two wires of the lead-in cable at the cabinet shall be twisted together and taped. The shield of the lead-in cable shall be grounded in the cabinet. At the detector housing, one megohm probe shall be connected to ground and the other probe shall be connected to one of the lead-in wires. The remaining lead-in wire shall be isolated. The test shall then be performed.

(c) Megohm Test After Splice is Completed at Cabinet

This test shall be performed after the splice at the detector housing is completed. A water solution of one tablespoon (15 ml) of baking soda per pint (0.5 L) of water shall be placed in a metal container. The metal container shall be grounded and the splice shall be fully submerged in the solution for 2 min. With the splice submerged, the megohm test shall be performed at the cabinet on the end of the lead-in cable.

(d) Vehicle Simulator Test

This test shall be performed after all other tests are completed and after all connections have been made at the controller in the cabinet. This test shall be performed by dragging a test vehicle across the loops using a non-conducting string. The test vehicle shall be fabricated with an 8 ft (2.4 m) length of No. 6 bare copper wire formed into a circle. The two ends shall then be electrically spliced. The detector unit amplifier shall record a call as the test vehicle is dragged across the loop. It shall cancel the call as the test vehicle leaves the loop.

(e) Acceptance Criteria

The Contractor shall record all test readings, in triplicate, on tabular forms provided by the Department or by copying the one included elsewhere herein. The Contractor shall complete, sign, and date the forms before submitting them to the District Traffic Engineer. The District Traffic Engineer will use these forms for recording the Department's readings on the corresponding space provided.

In order for the loop detector installation to be accepted, the electrical values shall be as follows:

1. Inductance shall be between 80 and 800 µH. Inductance shall be determined by means of digital readout meter which drives the field loop system.

2. Resistance shall be less than or equal to 8 ohms.

3. Voltage shall be less than or equal to 3 V.

4. Induced A.C. voltage and leadage resistance shall be greater than 100 megohms.

Loop wire and/or lead-in cable failing to meet this requirement shall be replaced at no cost to the State.

805.10 Magnetometer and Microloop Detectors

Before installation of Magnetometer or Microloop probes the Contractor shall confirm the adequacy of the magnetic field intensity, to be sure that the range is suitable for their operation. Arrangement of probes shall be located at maximum distance from steel support under bridges. Probes shall be installed with their long dimension vertical, and with the cable end at the top. Probes shall be firmly supported, so the lateral and vertical motion is restricted. Probes shall be connected in series. The splice shall be soldered by means of hot iron, or pouring or dripping without flames, with rosin core solder and shall be insulated and waterproofed in accordance with the manufacturer's specifications.

805.11 Steel Conduit

Conduit shall be installed to a depth of no less than 2 ft (0.6 m) or more than 5 ft (1.5 m) below the finished grade unless otherwise specified or approved. Pockets or traps where moisture might accumulate shall be avoided. Conduit shall be placed under existing pavement by approved jacking or drilling methods. Pavement shall not be disturbed without permission. If permission is granted, cuts in pavement areas shall be no greater than 24 in. (600 mm) wide. All cuts in the pavement and sidewalk areas shall be sawed. Sidewalk removal and replacement shall be to the nearest tooled joint. Jacking and drilling pits shall be kept at least 2 ft (0.6 m) clear of the edge of any type of pavement or paved shoulder. Excessive use of water that may cause undermining of the pavement shall be avoided. Continuous conduit runs shall not exceed 250 ft (76 m) in length, unless otherwise indicated on the plans.

Expansion fittings as detailed on structure plans shall be installed where conduit crosses an expansion joint in the structure. Where it is deemed inadvisable to install expansion fittings in closely confined areas, the installation of approved flexible tubing may be permitted. Such expansion joints or tubing shall be the same size as the conduit. Any existing underground conduit to be incorporated into a new signal installation shall be cleaned with a mandrel and blown out with compressed air before cable is drawn into pipe. All new conduit runs shall be cleaned and swabbed before cables are installed. All conduit ends shall be capped and shall remain capped until the Contractor is ready to pull cable into the conduit, at which time the caps shall be removed and conduit bushings placed on each end to protect the cable. The inside surface of the conduit shall be kept

clean. Conduit to be installed, indicated on the plans for future use of signal cables, shall be left in place with a pull cord on its entire length.

Larger size conduit may be used with no additional payment, but when it is used, it shall be for the entire length of the run from outlet to outlet. Conduit runs as shown on the plans are for bidding purposes only and may be changed, with permission, to avoid underground obstructions. A change order may be authorized if the conduit runs can be made on the opposite side of the street to that shown on the plans in order to avoid obstruction and traffic inconvenience or to avoid unnecessary tearing up of existing pavement.

805.12 PVC Conduit

The method of installing PVC conduit underground shall be the same as for steel conduit where applicable except trenches for the conduit shall be backfilled with 2 in. (50 mm) of sand before the conduit is placed in the trench. Materials excavated may be used for backfill, if approved. If the Engineer deems it necessary, approved B borrow shall be placed over the conduit to a depth of 12 in. (300 mm) and the remainder of the trench shall be filled with excavated material.

805.13 Foundations

Foundations for traffic signal poles, cabinets, and pedestals of the type specified shall be constructed, or existing M foundations shall be modified, as shown on the plans or as directed. Pedestal bases shall be plumb and firmly attached to the anchor bolts either by using leveling nuts or shims if top of the foundation is not level. Grouting shall be used when necessary to fill any gap between pedestal base and foundation. Pipe pedestals shall be screwed tightly into the bases and secured with a stainless steel pin. Power and signal cables shall then be pulled from the base into the cabinet. Curing of concrete shall be in accordance with 702.22.

During excavation of the foundation, all material shall be removed to the full depth as shown on the plans, except if class X material is encountered, the work shall be performed in accordance with 206.02(b).

805.14 Final Clean-Up

When the installation is completed, all disturbed portions of sidewalk, pavement, shoulders, driveways, sod, etc., shall be cleaned and any excess excavation or other materials shall be disposed. All cutting in the sidewalk and pavement areas shall be done with a saw. Sidewalk removal and replacement shall be to the nearest tool joint. Unless otherwise directed, cuts in pavement areas shall be no greater than 12 in. (300 mm) in width.

805.15 Method of Measurement

Traffic signal head, pedestrian signal head, pedestrian push button, controller cabinet foundation, M foundation modified to P-1 foundation signal steel strain pole, signal wood pole, signal cantilever structure, signal support foundation, signal service, disconnect hanger, magnetometer detector, microloop detector, loop detector delay amplifier, signal handhole, signal detector housing, span catenary and tether, and span catenary for flasher will be measured by the number of units installed.

Conduit of the type specified will be measured by the linear foot (meter) from outside to outside of foundations. Signal cable and signal interconnect cable will be measured by the linear foot (meter).

The accepted quantities for payment for electrical signal or loop lead-in cable will be the quantities shown in the Schedule of Pay Items. Such quantities may be corrected if they are in error by more than 25%.

Saw cut for roadway loop detector and sealant will be measured by the linear foot (meter) for the full depth of slot cut in the pavement as shown on the plans or as directed.

If class X material is encountered during foundation excavation, measurement will be made in accordance with 206.10.

Traffic signal installation or modernization, flasher installation or modernization, miscellaneous equipment for traffic signals, and final cleanup in accordance with 805.14 will not be measured for payment.

805.16 Basis of Payment

Traffic signal installation, flasher installation, traffic signal modernization, and flasher modernization, all of the type and the location number specified, will be paid for at a contract lump sum price.

If specified as pay items, traffic signal controller and cabinet, traffic signal head, pedestrian signal head, pedestrian push button, controller cabinet foundation, M foundation modified to P-1 foundation, signal steel strain pole, signal wood pole, signal cantilever structure, signal support foundation, signal pedestals, signal service, disconnect hanger, magnetometer detector, microloop detector, loop detector delay amplifier, signal handhole, signal detector housing, span catenary and tether, and span catenary for flasher will be paid for at the contract unit price per each. Conduit of the type specified, signal cable, interconnect cable, electrical signal cable, loop lead-in cable, and saw cut for roadway loop detector and sealant will be paid for at the contract unit price per linear foot (meter).

Class X excavation will be paid for in accordance with 206.11.

Miscellaneous equipment for traffic signals will be paid for at a contract lump sum price.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Controller and Cabinet, _____ (type), _____ (no.) Phase	EACH
Controller and Cabinet, Flasher, _____ (type)	EACH
Controller Cabinet Foundation, _____ (type)	EACH

Controller Cabinet Foundation, M, Modify to P-1 .....EACH
Disconnect Hanger .....EACH
Flasher Installation, Location No. _____ .....LS
Flasher Modernization, Location No. _____ .....LS
Handhole, Signal .....EACH
Loop Detector Delay Amplifier, _____ Channel .....EACH
no.
Magnetometer Detector .....EACH
Microloop Detector .....EACH
Miscellaneous Equipment for Traffic Signals .....LS
Pedestrian Push Button .....EACH
Pedestrian Signal Head, _____, _____ .....EACH
type lens size
Saw Cut for Roadway Loop and Sealant .....LFT (m)
Signal Cable, _____, No. _____ Copper, _____ C/ _____ .....LFT (m)
type conductors/size
Signal Cantilever Structure, Mast Arm _____ ft (m) .....EACH
length
Signal Detector Housing .....EACH
Signal Interconnect Cable, ____, No. ____ Copper, ____ C/ ____ .....LFT (m)
type conductors/size
Signal Pedestal, _____ ft (m) .....EACH
length
Signal Pole, Wood, _____, _____ ft (m) .....EACH
class length
Signal Service .....EACH
Signal Strain Pole, Steel, _____ ft (m) .....EACH
length
Signal Support Foundation, _____ in. (mm) x _____ in. (mm)
x _____ in. (mm) .....EACH
Span and Catenary for Flasher .....EACH
Span, Catenary, and Tether .....EACH
Traffic Signal Head, _____ Way, _____ Section, _____ .....EACH
no. no. lens sizes & colors .....EACH
Traffic Signal Installation, _____, Location No. _____ .....LS
type
Traffic Signal Modernization, _____, Location No. _____ .....LS
type

The cost of all wiring, hardware, anchor bolts, and associated equipment required to operate the intersections shall be included in the cost of controller and cabinet, flasher.

The cost of signal face hook-up wire, pole plates and arms for side mounts, mid-mast arm mount, pipe arms, signal brackets, visors, louvers, bulbs, span hanger, backplates, balance adjuster, weatherhead, and all additional hardware required to assemble a combination of signal faces as shown on the plans shall be included in the cost of traffic signal head or pedestrian signal head.

The cost of the push button, pedestrian actuated signal sign, and all hardware required to complete the installation shall be included in the cost of pedestrian push button.

The cost of concrete, conduits, grounding bushings, ground rod, ground wire, drainage, and all hardware required to complete the installation shall be included in the cost of controller cabinet foundation.

The cost of the base plate, metal skirt base plate, anchor bolts, handhole and cover grounding lug, 2 in. (50 mm) pipe cable entrance, J hook, and top cover as shown on the plans shall be included in the cost of signal strain pole, steel.

The cost of downguys, anchor rods, downguy guards, and hub-eyes as shown on the plans, and all hardware required to complete the installation shall be included in the cost of signal pole, wood.

The cost of all hardware including the metal skirt base plate, where necessary, to complete the installation as shown on the plans shall be included in the cost of signal cantilever structure.

The cost of concrete, reinforcing steel, conduits, ground rod, ground wire, grounding bushings, and all hardware required to complete the installation shall be included in the cost of signal support foundation.

The cost of the pedestal metal base, pedestal pole, pole cap when necessary, anchor bolts, and all hardware required to complete the installation shall be included in the cost of signal pedestal.

The cost of weatherhead, 1 in. (25 mm) conduit riser, entrance switch, 1 in. to 2 in. (25 mm to 50 mm) conduit reducer, ground rod, ground wire, and all hardware required to complete the installation, including the meter base when required and supplied by the utility company shall be included in the cost of signal service.

The cost of the detector unit, lead-in cable, and all work necessary for proper installation shall be included in the cost of magnetometer detector or microloop detector.

The cost of the slot cut on the pavement, sash cord, backer rod, loop sealant, and all testing in accordance with 805.09 shall be included in the cost of saw cut for roadway loop and sealant.

The cost of all work and hardware required to properly install overhead or underground signal cable as shown on the plans or as directed shall be included in the cost of signal cable and signal interconnect cable.

The cost of the independent shelf mount unit or card-rack unit, and power module shall be included in the cost of loop detector delay amplifier.

The cost of concrete reinforcing pipe, ring and cover eye bolts, hardware, handhole bottom, and aggregate under the handhole bottom as shown on the plans shall be included in the cost of handhole, signal.

The cost of aluminum casting, enclosure concrete, steel conduit and elbow, and all hardware required to complete the installation shall be included in the cost of signal detector housing.

The cost of steel pole bands or straight eye bolts, span, catenary, and tether of wire rope cables, cable rings, type A support cable, wire rope clips, safety cable, thimble, service sleeve, and all hardware required to complete the installation as shown on the plans shall be included in the cost of span, catenary, and tether for signal, or span and catenary for flasher.

The cost of excavation, backfill, final cleanup in accordance with 805.14, and necessary incidentals shall be included in the cost of the pay items in this section.

SECTION 806 – BLANK

SECTION 807 – HIGHWAY ILLUMINATION

807.01 Description

This work shall consist of installing wire, cable, conduit, lighting standards, luminaires, lamps, and incidental materials in accordance with 105.03.

Lighting installations shall be in accordance with the National Electrical Code and the National Safety Code.

807.02 Maintenance of Highway Illumination

Existing highway illumination shall be maintained on all projects unless discontinuance of the highway illumination is specifically permitted.

MATERIALS

807.03 Materials

Materials shall be in accordance with the following:

Casting for Handholes.....922.08
Coarse Aggregate, Class D or Higher, Size No. 53 904
Concrete, Class A.....702
Conduit.....922.10
Highway Illumination Materials 920.01
Line Hardware.....922.06(a)
Paint.....909
Reinforced Concrete Pipe 907.02
Reinforcing Steel.....910.01

Manufacturers' descriptive and technical literature for major items shall be submitted for approval. Where it is normal trade practice to furnish a warranty, a

warranty shall be furnished on all major items such as luminaires, lamps, poles, brackets, cable-duct, wire and cable, fuse connectors, and ballasts. The effective date of the warranty shall commence on the date of final acceptance. These items shall bear the seal of approval of the UL.

All flexible conduit shall be galvanized steel, polyvinyl jacketed, and watertight.

Reinforcing steel shall be epoxy coated.

CONSTRUCTION REQUIREMENTS

807.04 Excavation

All excavation for the roadway lighting installation shall be performed in accordance with the dimensions, elevations, and grades shown on the plans or as directed. If class X material is encountered, foundation excavation shall be completed in accordance with 206.

(a) Trench Excavation

Excavation may be accomplished either manually or with mechanical trenching equipment. The blades of road patrols or graders shall not be used to excavate the trenches. The depth of trenches shall be a minimum of 2 ft (0.6 m). Walls of trenches for cable-duct or conduit shall be essentially vertical. The bottoms of trenches shall be smooth and free from aggregate larger than 1/2 in. (13 mm). Bracing, shoring, and sheathing shall be provided as necessary. If the excavation, through accident or otherwise, is below the required level, the excess excavated area shall be refilled in a satisfactory manner with no additional payment. The accumulation of water in excavated areas shall be prevented by the use of pumps or other approved means. When rocks or other materials which might damage the cable-duct or conduit are encountered, the excavation shall be extended to a depth of at least 27 in. (700 mm) and backfilled with a 3 in. (75 mm) compacted layer of sand or earth containing no particles that would be retained on a 1/4 in. (6.3 mm) sieve. No extra payment will be made for this additional excavation or backfill.

(b) Foundation Excavation

If possible, excavation for concrete foundations shall be accomplished by means of drilling with an auger of sufficient size to admit the width of the foundation. Work shall be so scheduled that all open excavations are poured with concrete during the work day they are dug. No excavations shall remain open over night or over a weekend or holiday. Accumulated water shall be removed from the excavation before concrete is poured. If class X material is encountered, foundation excavation shall be completed in accordance with 206.02(b).

(c) Landscape Replacement

Where roadside shrub plantings interfere with the location of illumination installations, the plantings shall be reset at other locations and at such times as directed, all in accordance with 622. The cost of this work will not be paid for directly, but shall be included in the cost of other pay items.

All slopes for foundation grading shall be sodded. Sod shall be placed in accordance with 621.

807.05 Backfilling

Wherever practicable, all suitable materials removed from the excavated areas shall be used in refilling cable-duct and conduit trenches. No excavated materials shall be wasted without authorization. Materials authorized to be wasted shall be disposed of as approved. Backfill for trenches shall be placed in layers not to exceed 6 in. (150 mm), loose measurement. The first layer shall be sand or earth containing no particles or lumps that would be retained on a 1/4 in. (6.3 mm) sieve. The second layer shall contain no particles or lumps that would be retained on a 1 in. (25 mm) sieve. Subsequent layers shall contain no particles or lumps that would be retained on a 3 in. (75 mm) sieve. The second layer and each subsequent layer shall be compacted with pneumatic hand tamps to the satisfaction of the Engineer to prevent any future settlement of the backfilled area. Backfilling of cable-duct and conduit trenches around lighting standard foundations, handholes, manholes, and other structures shall be in accordance with the applicable provisions of 211. Finish grading of earthwork shall be accomplished in a satisfactory manner.

807.06 Placing Conduit

Conduit shall be placed as shown on the plans and in accordance with applicable provisions of 805.11. Conduit shall be of a size to readily permit the passage of the cable-duct being used.

Conduit installed under pavement shall extend a minimum of 2 ft (0.6 m) beyond the edge of the paved surface or improved shoulder. The ends of such conduit shall terminate a nominal 2 ft (0.6 m) below the ground surface. The ends shall be pitched so as to provide a positive drain to the surrounding soil. The ends shall be protected by threaded cap fittings until the time of installation of cable or cable-duct. Threaded bushing fittings shall be used on all ends before cable installation.

Conduits installed in bridge railing concrete sections shall terminate a minimum of 2 ft (0.6 m) beyond the end of the bridge railing outside of the paved surface and a minimum of 2 ft (0.6 m) under the ground surface. Existing conduit shall be extended as necessary to satisfy these requirements.

Hot dipped galvanized, malleable pipe straps and spacers shall be used to attach conduit to bridge structures. Galvanized steel conduit hangers or pipe clamps will not be permitted. Pipe straps of the proper size shall be installed 4 ft (1.2 m) center to center along the conduit. When fastening pipe straps to concrete, a 3/8 in. by 2 1/2 in. (9.5 mm by 63 mm) galvanized steel lag screw, with an approved sleeve, shall be used; however, other approved expansion anchors may be used. The pipe strap and spacer shall be bolted to the steel beams.

Conduit for service supply shall be mounted on a service pole, either company or State owned, near the right-of-way line. For simple supply circuits, one straight, continuous, conduit riser shall be used. The top end shall terminate with a weatherhead device, and the lower end shall terminate at least 2 ft (0.6 m) below ground level with a threaded grounding bushing fitting. Unless otherwise directed, the weatherhead shall be

24 ft (7.3 m) above the ground. However, the actual elevation of the weatherhead shall meet the requirements of the utility concerned.

807.07 Connections in Base of Lighting Standards

Conductors shall be electrically bonded to each other, as required to satisfy circuit requirements, by means of compression type fittings of the style and type shown on the plans. Inhibitor compound shall be used on each compression connection. Conductor identification shall be maintained by connecting like color connectors.

A multiple conductor compression fitting shall be used to connect supply conductors and an insulating link used to provide an extension as shown on the plans. These fittings shall be covered with snap-on fiber or plastic covers designed to protect them from electrical contact. Taping will not be permitted. The bare extension of the supply conductor from the multiple fitting to the insulation link shall be no longer than necessary to admit the application of the snap-on cover for the multiple fitting.

The pole circuits shall be connected by means of easily separated, single conductor connector kits. The connector kit on the "hot" side of the pole circuit shall be fused. The connector kit for the neutral side shall not be fused. Fuses shall be of the "KTK" series with a rated capacity three times the operating amperage of the luminaire. If the required capacity is not a standard size, the next larger size fuse shall be used.

The connector kit on the "hot" side of the pole circuit shall have the following features:

(a) a line side and load side housing made of plastic or water resisting synthetic rubber suitable for direct burial in the ground or installation in sunlight;

(b) a water seal between the two housings;

(c) each housing permanently marked "Line Side" or "Load Side";

(d) a spring loaded, 90% minimum conductivity, contact suitable for gripping the "KTK" cartridge fuse in each housing. These contacts shall be fully annealed;

(e) an interior arrangement for each housing that will adequately receive and rigidly maintain the fuse contacts;

(f) a terminal on each housing designed for a crimp type connection to the conductor that securely retains the conductor in the proper position;

(g) a water seal between the conductor and the housing;

(h) a disconnecting means that shall retain the fuse on the load side when disconnected and keep the conductive parts of the line side inaccessible; and

(i) sufficient silicone compound provided and used to lubricate the metal parts and the rubber housings or boots for easy assembly.

The neutral side connector kit shall be similar in all respects to that described for the hot side except that a dummy fuse shall be used for the purpose of completing the electrical circuit. The bayonet disconnect feature of the connector kits shall be part of the load side of both the neutral side and the hot side conductors. The line side shall have a socket to receive the bayonet. These kits shall be installed in the pole circuit between the luminaire terminals and the compression connection to the underground distribution circuit as shown on the plans. A separate insulated conductor shall be used to connect the neutral of the underground distribution circuit and the neutral of the pole circuit to the ground lug in the pole base from the point at which both neutrals are connected together by a compression connection. The bayonet disconnect features from the neutral side and the hot side connector kits as cited above shall be included in the sign structure circuitry when luminaires are installed on the sign structures. Consecutive roadway luminaires in a circuit shall be alternately connected to opposite load conductors R or B as specified in the plans to balance the load. Sign luminaires on individual structures shall be similarly connected.

807.08 Placing Wire and Cable

(a) Underground Through Cable-duct

All underground distribution conductors shall be continuous runs between splice points. Unless otherwise authorized, splice points shall be inside the bases of lighting standards, inside handholes, in service distribution boxes, at point of connection to power supply in switch boxes, or in junction boxes. All splices shall be made with the proper connector in accordance with 807.07.

1. Cable-duct

Cable-duct shall be placed either in a trench or plowed into place. Cable-duct shall be installed without sharp bends or kinks and in straight runs so as to permit withdrawal of a conductor and the installation of new conductor without additional excavation or backfill.

Plowed cable-duct shall be installed at a minimum depth of 2 ft (0.6 m) in a single cavity gored into the earth by a vibrating plow blade. The equipment used for plowing the cable-duct shall be designed specifically for that purpose with the power and versatility to easily and accurately bury the various sizes of cable-duct under all normal soil conditions. This equipment shall place the cable-duct without twisting, kinking, or damaging it in any way. Dragging or pulling the cable-duct from the start of the trenching operation will not be permitted. Where two ducts are to be installed parallel to each other, the distance between them shall be no less than 12 in. (300 mm) nor more than 24 in. (600 mm).

The plastic duct of the cable-duct shall be terminated 4 in. (100 mm) above the top of foundations or 4 in. (100 mm) inside handholes with sufficient excess conductors as directed. All terminations of this plastic duct shall be beveled free from any sharp edges or burrs. Insulation of the electrical conductor shall not be damaged when cutting the duct.

2. Cable Markers

The location of underground conduits or cable-ducts shall be marked with cable markers. The marker shall be placed at all changes in direction, where the underground distribution circuit is split, and at a maximum of 400 ft (122 m) intervals on straight runs. Cable markers shall be a slab of concrete 2 ft (0.6 m) square by 4 in. (100 mm) thick, with the word "Cable" die impressed into the surface of the marker, a minimum depth of 3/8 in. (10 mm) with letters a minimum of 2 in. (50 mm) high. Arrows showing the direction of the cable shall be die impressed or sawcut a minimum depth of 3/8 in. (10 mm) into the marker surface.

Curing of the concrete shall be in accordance with 702.22. The cable marker shall have a smooth metal trowel finish without scaling.

(b) Underground Through Conduit

The underground distribution circuit shall be protected by galvanized steel conduit when installed under pavement, in road shoulders, or elsewhere as shown on the plans or as directed.

1. Cable-duct

Cable-duct shall be pulled through the entire length of galvanized steel conduit if at all possible. If this is not possible, written authorization shall be obtained to permit the duct to be cut away and the conductors installed in the conduit with a minimum of 2 ft (0.6 m) of duct extended into the conduit. Where so authorized, the plastic duct shall be terminated in the proper transition fitting attached to the end of the conduit and each conductor of the cable-duct assembly shall continue undamaged and uninterrupted through the galvanized steel conduit to the other end of the conduit where a transition to the cable-duct shall be used again and the cable-duct shall continue uninterrupted to the next designated splice point. All transitions from galvanized steel conduit to cable-duct shall be accomplished with the proper adapter. This adapter shall provide a durable, watertight transition that has a smooth uniform interior.

2. Cable Markers

Cable markers shall be in accordance with 807.08(a)2.

(c) In Conduit Risers

Cable-duct shall enter the bottom of the conduit riser with a sweeping radius bend and continue up the riser to within 3 in.(75 mm) of the top of the conduit riser. At this point the plastic duct shall be terminated and the conductors shall continue uninterrupted and undamaged into the service cabinet, underpass switchbox, or through the weatherhead with sufficient excess to make the required connections.

(d) Through Conduit in Bridge Coping

Where a cable-duct underground distribution circuit is run through conduit installed in bridge coping, the duct shall be cut away and the conductors shall be installed in the conduit with at least 2 ft (0.6 m) of duct extended into the conduit. The conductors, through this transition, shall be continuous between authorized splice points. Where more than one lighting standard is to be installed on the same side of the bridge structure and connected to the same distribution circuit, the cables pulled between these lighting

standards shall be of the same type and size used in the cable-duct underground distribution circuit.

(e) Aerial Cable

Aerial cable for overhead distribution circuits shall be supported and terminated as shown on the plans. The aerial cable shall have a sag of no more than 5% of the distance between lighting poles except where slack spans are indicated on the plans. Aerial cables shall have a minimum vertical clearance of 18 ft (5.5 m).

807.09 Lighting Handholes

Handholes shall not be placed in areas subject to flowing or ponding water. Handholes shall be installed with the top flush with adjoining surfaces. Precast handholes with integral bottoms will be considered acceptable.

Multiple compression fittings and insulating links installed in handholes shall be taped and waterproofed by application of an approved waterproofing device. The insulation around the area to be waterproofed shall be cleaned before applying the waterproofing device. These waterproofing devices shall be designed for insulating multi-conductor cables with a minimum voltage carrying capacity of 600 volts.

Heavy weave fiberglass reinforced polymer concrete service boxes will be permitted as an acceptable substitute for a street and alley handhole providing that they can be placed at a location which meets both of the following conditions:

(a) there is no evidence of vehicles traveling over the area where the handhole is to be located; and

(b) it is located a minimum of 15 ft (4.6 m) from the edge of pavement, unless it is protected by guardrail, unmountable curb, a structure, or an untraversable ditch.

The handhole shall be backfilled with sand or earth containing no particles that would be retained on a 1/4 in. (6.3 mm) sieve. The backfill shall be placed as shown on the plans. No additional payment will be allowed for this backfill.

807.10 Concrete Foundations For Lighting Standards

Foundations shall be class A concrete in accordance with 702. Footings may be either round or square in shape as shown on the plans.

Anchor bolt circle dimensions shall be furnished and the anchor bolts shall be in accordance with 920.01(a)7. A rigid template shall be used to center the anchor bolts in the foundation. Unless otherwise specified, the template shall be oriented so that the mast arm of the lighting standard is perpendicular to the center line of the roadway.

Each foundation installation shall have provisions for grounding the lighting standard in accordance with 807.12. The tops of the concrete foundations shall be constructed level and only shims used to rake the lighting standard will be permitted. Shims will not be permitted with break-away couplings. Each foundation shall have an

imprinted arrow or arrows on the top of the foundation to indicate the direction of the cable duct run.

Foundations for high mast towers shall be constructed prior to constructing foundations for conventional roadway lighting.

(a) Cast-in-Place Foundations

If the sidewalls of the excavated areas remain firm and stable, concrete may be poured directly against the dirt below the level of the top 6 in. (150 mm) form. Otherwise, the concrete foundation shall be fully formed by means of a paper preformed liner or other approved means. However, the foundation shall be formed to the proper size for the top 6 in. (150 mm) before concrete is poured. If a paper liner is used, it may be withdrawn as the concrete is placed or it may be left in place permanently. If the liner is left in place, all voids between the excavation walls and the form shall be filled and compacted using coarse aggregate No. 53. If the liner is withdrawn, the top 12 in. (300 mm) of the foundation shall remain formed until the concrete has obtained initial set.

(b) Precast Foundations

Precast foundations shall be complete with reinforcing bars, tie bars, anchor bolts, and entry sleeves located to provide a level mounting for the lighting standard after installation. The grounding coil, as shown on the plans, may be used for grounding lighting standards set on precast foundations. Foundation backfill shall consist of coarse aggregate No. 53.

(c) Grading of Foundations

Foundation projection above the finished grade shall be as shown on the plans. The excavated material may be used for this grading if it is not granular in nature and will readily stabilize and support the growth of sod. If the excavated material is unsuitable, it shall be properly disposed of and approved materials used. The area shall be sodded. Sodding will be in accordance with 621.

807.11 Placing Lighting Standards

(a) Lighting Standards Under 80 ft (24 m) in Height

The lighting standard assembly shall consist of a metal pole, a shoe base, a frangible breakaway base or coupling where shown on the plans, and a metal mast arm for attaching the luminaire. The unit shall be assembled on the ground. Pole circuit wiring shall be installed and the luminaire shall be attached prior to erection. The factory finish of the pole assembly shall be protected from mars, blemishes, scratches, or other damage. Slings and chokers for lifting purposes shall be of nylon or other approved material. Chains, metal rope, or other abrasive materials will not be permitted for lifting devices. If damage to the factory finish occurs, repair or replacement shall be as directed.

The base plate shall be designed to carry the pole assembly. The plate assembly shall be supported by a transformer base, which shall be in accordance with the breakaway requirements in the AASHTO Standard Specifications for Structure Supports for Highway Signs, Luminaires, and Traffic Signals.

After erection and attachment to the foundation, the pole assembly shall be plumb. The luminaires shall be level in both horizontal areas. Shims will not be permitted with breakaway couplings. Shimming will be permitted on other types of installations to rake the pole assembly to obtain the desired attitude of the luminaire where the combined weight of the pole and mast arm requires it and the luminaire saddle will not permit the adjustment. The mast arm shall be perpendicular to the axis of roadway travel unless special orientation is noted on the plans. Unless otherwise specified, the lighting system shall consist of metal pole supports for the luminaires with an underground electrical supply system.

(b) High Mast Lighting Standards of 80 ft (24 m) Height and Over

High mast light pole sections shall be mechanically fitted in the field using factory supplied hydraulic jack or hoist puller that shall produce a minimum force of 10,000 lb (44.5 kN) per side. Field assembly procedures and assembly apparatus requirements shall be submitted for approval. Field welds will not be permitted except where shipping limitations prevent permanent factory assembly. Prior approval for field welds is required.

The pole shall be erected on the lower set of the anchor bolt nuts and secured with the top nuts. The adjustments to plumb the pole shall be made prior to the final tightening of the top nuts.

The pole shall be plumbed under no wind conditions before sun-up, after sun-down, or on an overcast day. The deviation from vertical shall not exceed 1/4 in. (6.5 mm) within any 10 ft (3 m) of height.

When installing the high mast power cable, one end of the power cable shall be securely connected to the luminaire ring. The other end of the power cable shall be secured to the support and terminated 3 ft (0.9 m) below this support with a heavy duty three wire electrical plug. Adjustments of the three support cable lengths shall be made prior to lowering the ring for the first time. After the support cables have been adjusted and the luminaires installed on the ring, at least one complete cycle operation of the ring shall be conducted on each structure.

807.12 Grounding

Ground wire shall be No. 6 solid bare copper. Ground rods shall be 1/2 in. (13 mm) diameter by 8 ft (2.4 m) long copper weld ground electrodes except where larger sizes are specified. The top of the ground rod shall be driven at least 6 in. (150 mm) below grade. Ground rods shall not be installed within the lighting standard, sign structure, or high mast tower foundations.

The ground wire shall be connected to the top or side of the ground rod. The ground rod, ground wire connection shall be made by a thermo weld process. The wire and ground rod shall be free of oxidized materials, moisture, and other contaminates prior to inserting the wire and the ground rod into the properly sized mold. The welding material shall sufficiently cover and secure the conductor to the rod. The completed connection shall be non-porous.

As an acceptable substitute to this process, a mechanical ground grid connection of an approved type may be used. Tap type clamps, parallel type clamps, U-bolt flat clamps, and crossover clamps will not be accepted.

Luminaire standards shall be grounded by connecting the free end of the ground wire to the grounding lug in the transformer base or pole. The free end of the ground wire shall enter the pole base through the entry sleeve installed in the foundation.

The neutral conductor of the underground distribution circuit shall be connected to the ground lug in the transformer base or pole. This connection shall include a quick-disconnect type connector kit so that in the event of a pole knockdown the connection will readily break without damage to the buried conductor.

The breaker boxes for the sign and underpass circuits shall be grounded by connecting the free end of the ground wire to the neutral grounding terminal in the breaker box and connecting this terminal to a grounding lug securely fastened to the metal interior of the breaker box. The conduit terminating in the breaker box and the sign or underpass luminaire housing shall have a good, clean, tight connection and act as a grounding conductor for these luminaires. The neutral conductors of the feed and distribution circuits for underpass and sign illumination shall be connected to the neutral grounding terminal in the switch box or breaker box. The neutral conductor of the distribution circuit for underpass and sign illumination shall be grounded in each luminaire by connecting a jumper from the neutral terminal of the luminaire to a ground lug fastened to the metal housing of the luminaire.

Sign structures shall be grounded at one sign column by connecting the free end of the grounding wire at that column to the grounding lug in the column base.

A type I service for supply of electrical energy shall consist of a conduit riser to a weatherhead. This conduit shall be grounded at the lower end by means of a standard strap grounding connection to the ground wire and ground rod. A type II service shall consist of a multiple number of conduits from underground to the bottom of the service cabinet and a single conduit to a weatherhead from the top of the service cabinet. All of these conduits shall be connected by a single ground wire from the grounding terminal to a grounding bushing for each conduit within the interior of the service cabinet. In addition a ground wire from the grounding terminal of the service cabinet shall be connected through a conduit to a ground rod.

Bridge railing conduits shall be grounded at each end of the bridge railing by means of a standard grounding strap connected to a ground wire and ground rod. The ends of the conduits terminating in a bridge anchor location shall provide ground continuity by means of a grounding bushing on each conduit end and the connection of the bushing to a ground wire.

All equipment used in the highway lighting system shall be grounded. If necessary, additional grounding shall be installed as directed.

807.13 Luminaire Installation

Luminaire installation shall consist of the physical placing of the luminaire. Each installation shall include the furnishing and placing of the lamp as designated.

(a) Roadway Luminaires

Each luminaire shall be leveled in both directions in the horizontal plane after the light standard has been erected and adjusted. Rotary adjustment of the mast arm and vertical adjustment of roadway luminaires to obtain an installed level position in both directions shall be accomplished by means of the bolted saddle arrangement used to attach the luminaires to the mast arm. Lamp socket positions may be shown on the plans by type of Illuminating Engineering Society of North American (IES) light pattern. The specified lamp socket position shall be used to obtain the desired light pattern delivery. Proper connections shall be made to provide ballast operation at the voltage being supplied. Replacements needed because of faulty or incorrect voltage connections shall be made with no additional payment.

(b) Sign Luminaires

Connections in which plain and galvanized steel are in contact shall be protected such that aluminum surfaces shall receive one coat of zinc chromate primer. Steel surfaces shall receive one coat of inorganic zinc primer followed by one coat of aluminum paint. All paint shall be permitted to dry before assembly. Conduit fittings, if required, shall be watertight. Required conduit shall be either rigid or flexible as necessary. Conduit shall not be clamped to a sign panel.

Sign luminaires shall be mounted on overhead sign structures on two metal channels located at the extremity of the sign walkway support brackets. The distance between lighting unit support channels shall be 7 in. (180 mm). These channels shall be located in such a manner that they readily receive the mounting bolts from the rear of the sign luminaire. The installation of the sign luminaire shall consist of the physical placement of the luminaire on the channels.

Sign luminaires shall be connected to a phase conductor and a neutral conductor. The luminaires shall be alternately connected to opposite phase conductors to balance the load. The connections in the base of the sign structure shall be in accordance with 807.06. Conductor splicing shall be in junction boxes, in-ground handholes, inside handholes of sign structures, and circuit breaker enclosures.

(c) Underpass Luminaires

Underpass luminaires shall be mounted on the vertical side surfaces of bridge bent structures or suspended by means of pendants supported by angle-iron struts or clips fastened to the structural beam members of the bridge. All parts of the pendent pipe assembly shall be hot-dipped galvanized after threads are cut. Silicone caulking compound shall be applied to the threads during assembly of the pendent. Underpass luminaires may require separately mounted ballasts which shall be installed in close proximity to the luminaires.

Underpass luminaires shall be connected to a phase conductor and a neutral conductor. The luminaires shall be alternately connected to opposite phase conductors to

balance the load. Conductor splicing will only be allowed in junction boxes, in-ground handholes, and circuit breaker enclosures.

(d) High Mast Luminaires

The aiming of the luminaires shall be as shown on the plans. When the aiming process is being done the luminaire shall be oriented to conform to its raised position and the ring properly tethered to prevent rotation during the aiming adjustment. The long axis of the luminaire shall be parallel to the aiming direction indicated on the plans.

807.14 Sign, Underpass, Roadway, and High Mast Lighting Location Identification

All high mast towers, roadway light standards, underpass lighting installations, and sign lighting installations shall have an identification code number as shown on the plans. In addition, each luminaire at a sign or underpass installation shall be individually identified with a single capital letter.

The code number shall be displayed on the light standard, sign structure column, and high mast tower as shown on the plans. The underpass code number shall be displayed near the breaker box at a location as directed.

The code number for the lighting standard and sign structure column shall be applied to the pole, as specified by the manufacturer, by using individual, pressure sensitive, adhesive backed tags. The code number for the high mast tower shall be applied to an aluminum plate which is mounted with spacers away from the structure as shown on the plans.

807.15 Service Point Power Entry

The utility's requirements for service locations shall be coordinated. Unless otherwise specified, a pole shall be furnished for the service point. If the utility requires metering of the lighting system, a meter socket shall be obtained from and installed in accordance with the requirements of the utility. Grounding shall be in accordance with 807.12 and shall be a part of the service installation.

Energy shall be provided with 120/240 V service or 240/480 V service with the proper KW capacity on poles located immediately inside the right-of-way at locations designated on the plans. Electrical materials incorporated in the work shall be compatible with the service voltages supplied by the local utility.

The service voltages supplied by the local utility shall be checked for compliance with the planned voltages. If a discrepancy exists, it will be resolved as directed before work is started or any electrical equipment is purchased.

(a) Types of Service Points

Service point installations shall be of two types as shown on the plans.

1. Type I Service Point

This service point installation shall consist of class 5 wood pole, 2 3/4 in. (70 mm) galvanized steel conduits, weatherhead, photo cell and multiple relay switch. The conduit riser shall be fastened and supported on the pole by means of galvanized

hook pipe straps and secured to the pole by means of a galvanized lag screw all of the proper size for the conduit being installed. Cable-duct shall be installed in the conduit riser in accordance with 807.08(c). The conductors shall extend beyond the weatherhead a minimum of 4 ft (1.2 m). The conductors outside of the weatherhead shall be ringed to prevent moisture from entering the conduit enclosure.

2. Type II Service Point

This service point installation shall consist of a service cabinet with a single galvanized steel or aluminum conduit riser to the weatherhead. A multiple number of galvanized steel conduits shall extend from the bottom of the service cabinet in accordance with 807.06. Underground cable-duct shall be installed in accordance with 807.07(c). Connections, connectors, and fixtures shall be as shown on the plans.

The service cabinet shall be secured to the pole by means of a galvanized steel channel post or other approved device.

(b) Sign and Underpass Circuits

The illumination circuits for sign structures with an overhead power supply shall be protected by circuit breakers mounted on the end support.

Circuits for adjustable end support sign structures, bridge bracket signs, or underpasses shall be protected by circuit breakers mounted on the bridge or sign structure and connected to the underground distribution circuit in a handhole.

Circuits for sign structures with an underground power supply shall be protected by fuse connector kits in the base of the sign support. The fuse connector kits shall include bayonet disconnect features for the “neutral” side and “hot” side.

(c) Multiple Relay Switches

Unless otherwise specified, wood pole, multiple relay switches, service cabinet, photocells, photocell receptacles, weatherhead, conduit, and other miscellaneous items shall be furnished and installed as a part of the service point.

807.16 Testing of Highway Lighting System

(a) Testing Lighting Circuitry

All necessary equipment and apparatus properly calibrated for testing the lighting circuits shall be furnished. The supplying utility shall be given advance notice of the test scheduling so their representative may witness the testing procedures if desired. Each main lighting circuit, including its branches, shall be tested for insulation resistance and continuity after it is completely installed but before the pole circuits, underpass circuits, sign circuits, and grounding circuits are connected. The insulation resistance test shall be made with a megohm meter and the resistance to ground shall be no less than 50 megohms in all lighting circuit power cables. The meter shall be set for the voltage rating of the insulation. The continuity test shall be made with an ohmmeter properly scaled for measuring the resistance of the power cables. This test shall verify the following:

1. That each power cable is continuous to its termination points.

2. That the cable coding at junction and termination points is consistent with cable coding at the supply point.

3. That power cables are not crossed with the neutral or each other.

4. That the main circuit through each of its branches does not have unusual resistance values.

The entire completed installation shall be tested by circuit or by such portions as may be selected and at night if directed. Tests shall demonstrate the following:

1. That all power, lighting, and control circuits are continuous, free from short circuits, and free from unspecified grounds.

2. That all circuits are properly connected in accordance with applicable wiring diagrams.

3. That all circuits are operable which shall be demonstrated by continuous operation of each lighting circuit for at least 1 h.

4. That voltage at the ends of each lighting circuit and at inter points is within allowable limits. A maximum of 10% voltage drop will be permitted for each complete circuit.

(b) Testing and Inspecting Luminaires

The lighting system from the service point through the last luminaire shall be subjected to 14 days of normal operation prior to final acceptance. This testing procedure may be conducted separately on each circuit or on the entire system.

Normal operation is defined as the luminaires being on during the darkness hours and off during the daylight hours as controlled by the service point photocells and relay switches. Malfunctioning equipment shall be replaced or repaired before final inspection. The pattern of light delivered to the pavement by roadway and high mast luminaires will be inspected at night. At this inspection, the proper tools, equipment, and personnel shall be available to make all adjustments. These items shall specifically include a bucket truck capable of reaching all luminaires in the system, safety equipment, and a level to determine the proper luminaire position.

807.17 Pay Item and Installation Summary Sheets

Prior to final inspection, two sets each of shop drawings, installation summary, and pay item summary marked Final Record shall be furnished for the light standards as installed. The installation summary shall show the effective mounting height, arm length, foundation elevation, pay item, type of base, and catalog number or drawing for each light standard furnished. The pay item summary shall indicate the pay item, quantity, effective mounting height, arm length, and type of base for each type of lighting standard furnished.

807.18 Method of Measurement

Luminaire, light standard with mast arm, high mast standard, identification number, connector kit, multiple compression fitting, insulating link, foundation, handhole, service point, and cable marker will be measured by the number of units installed. Pole circuit conductor and circuit conductor in conduit will be measured by the linear foot (meter). Pole circuit conductor will be measured from the base of the lighting standard to the terminal block of the luminaire. Pole line extension will be measured in a straight line between each pole.

Conductor in bridge conduit will be measured by the linear foot (meter) from end to end of conduit or from the end of conduit to the last bridge light pole foundation entry. An allowance of 5 lft (1.5 m) will be made for each foundation entry. An allowance of 2 lft (0.6 m) will be made for each junction box.

Removal of existing light structure, which shall include the pole, mast arm, and foundation, will be measured by the number of units removed.

Cable-duct and conductor in underground duct or conduit will be measured by the linear foot (meter) as follows:

(a) From the face of the concrete foundation to the center of the handhole or face of the next concrete foundation. An allowance of 5 lft (1.5 m) will be made for each entry at foundations. An allowance of 2 lft (0.6 m) will be made at handholes for connection purposes.

(b) From lighting standard bases or handholes to switch boxes at underpasses. An allowance of 4 lft (1.2 m) will be made at the switch box for electrical connections.

(c) From end to end of the conduit when the cable is in conduit under a roadway surface or shoulder. No measurement will be made of cable-duct in conduit where it is part of a service point, sign installation, or underpass lighting system.

807.19 Basis of Payment

Luminaire will be paid for at the contract unit price per each for the type and wattage specified. Service point will be paid for at the contract unit price per each for the type specified. Light pole will be paid for at the contract unit price per each for the estimated mounting height, length of mast arm, and base type specified.

Lighting foundation, concrete, with grounding will be paid for at the contract unit price per each for the size specified. If class X material is encountered during lighting foundation excavation, payment will be made for such excavation in accordance with 206. Partial payment for lighting foundation in the amount of 80% will be made if all such work is complete except for finish grading and sodding. The remaining percentage of payment will be made upon completion of the finish grading and sodding.

Connector kit will be paid for at the contract unit price per each for fused or unfused, as specified. Multiple compression fitting and insulation link will be paid for at

the contract unit price per each for waterproofed or non-waterproofed, as specified. Cable-duct marker, high mast tower winch drive, and handhole, lighting will be paid for at the contract unit price per each. Sign, underpass, and roadway lighting location identification will be paid for at the contract unit price per each. Circuit installation will be paid for at the contract unit price per each for the type, structure number, and number of luminaires specified. Light structure, remove and portable tower lighting drive system will be paid for at the contract unit price per each.

Wire will be paid for at the contract unit price per linear foot (meter) for the designation, copper gage, housing, and number of conductors specified. Pole circuit cable, THWH, stranded will be paid for at the contract unit price per linear foot (meter) for the copper gage and number of conductors specified. Conduit, steel, galvanized, 2 in. (50 mm) diameter will be paid for at the contract unit price per linear foot (meter).

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Cable-Duct Marker	EACH
Cable, Pole Circuit, THWH, No. _____ Copper Stranded, _____ _____/C	LFT (m)
Circuit Installation, Str. No. _____, _____ Luminaires (no.)	EACH
Conduit, Steel, Galvanized, 2 in. (50 mm)	LFT (m)
Connector Kit, Fused	EACH
Connector Kit, Unfused	EACH
Handhole, Lighting	EACH
High Mast Tower Winch Drive	EACH
Insulation Link, Non-waterproofed	EACH
Insulation Link, Waterproofed	EACH
Lighting Foundation, Concrete, with Grounding, _____ in. (mm) x _____ in. (mm) x _____ in. (mm)	EACH
Light Pole, High Mast, _____ ft (m) E.M.H.	EACH
Light Pole, Roadway, _____ ft (m) E.M.H., _____ ft (m) Mast Arm, _____ Base	EACH
Light Structure, Remove	EACH
Luminaire, High Mast, _____, _____ Watt (type)	EACH
Luminaire, Roadway, _____, _____ Watt (type)	EACH
Multiple Compression Fitting, Non-Waterproofed	EACH
Multiple Compression Fitting, Waterproofed	EACH
Portable Tower Lighting Drive System	EACH
Service Point, _____ (type)	EACH
Sign, Underpass, and Roadway Lighting Location Identification	EACH
Wire, _____ (designation), No. _____ Copper, in _____ (housing), _____ _____ /C	LFT (m)

The cost of lamps, ballast, optical systems, weatherproof housings, and electrical connections shall be included in the cost of luminaire.

The cost of the mast arm, J-support hook for pole circuit, handhole with cover, shoe base, transformer base or frangible coupling if required, installation on the foundation with the pole circuit, and luminaire installation shall be included in the cost of light pole.

The cost of the pole; lowering system including winch assembly, power cable, and support cable; concrete pad; luminaire ring; anchor bolts and nuts; lightning rod assembly; grounding system; and all incidental materials necessary to complete the installation shall be included in the cost of light pole, high mast. The cost of excavation, concrete, sleeves for cable-duct, non-metal pipe, reinforcing steel, backfill, finish grading, and sodding shall be included in the cost of lighting foundation.

The cost of aerial distribution service, drops to sign structures branching off from the pole line extension, weatherheads and risers required to connect the line extension to the underground electrical distribution circuit, all anchorage guy wires, hardware, aerial cable, electrical connections, wood poles, and incidentals required to complete the pole line extension shall be included in the cost of cable, pole circuit.

The cost of snap-on covering in light pole base and waterproof covering in underground handhole shall be included in the cost of multiple compression fitting.

The cost of circuit breakers; breaker enclosures; conduit; flexible conduit; conduit fittings; grounding; weatherhead; aerial cable termination; and incidentals required from the last luminaire to the point of attachment by the utility, the bottom of the riser at the structure base, or the connector kits in the base of the sign supports shall be included in the cost of circuit installation.

The cost of maintaining highway illumination during the life of the contract shall be included in the cost of other pay items.

SECTION 808 – PAVEMENT TRAFFIC MARKINGS

808.01 Description

This work shall consist of furnishing and installing, or removing, pavement traffic markings and snowplowable raised pavement markers in accordance with the MUTCD, these specifications and as shown on the plans. Markings shall be installed as required unless written approval is obtained from the District Traffic Engineer to make modifications at specific locations.

MATERIALS

808.02 Materials

Materials shall be in accordance with the following:

Cones.....801.08
Epoxy .....921.02(c)

Glass Beads .....921.02(e)
Preformed Plastic .....921.02(b)
Snowplowable Raised Pavement Markers .....921.02(d)1
Thermoplastic.....921.02(a)
Traffic Paint 909.05

CONSTRUCTION REQUIREMENTS

808.03 General Requirements

Permanent pavement markings shall be placed on the surface course in a standard pavement marking pattern. Center lines shall be placed on two-way two-lane roads, lane lines shall be placed on multi-lane divided roads, and both center lines and lane lines shall be placed on multi-lane undivided roads. The markings shall be of the same material as the existing pavement markings or any durable pavement marking material.

The pavement shall be cleaned of all dirt, oil, grease, excess sealing material, excess pavement marking material and all other foreign material prior to applying new pavement traffic markings. New paint pavement markings may be placed over sound existing markings of the same color. New thermoplastic, preformed plastic, or epoxy markings may be applied over sound existing markings of the same type if permitted by manufacturer's recommendations, a copy of which shall be supplied to the Engineer prior to placement; otherwise, existing markings shall be removed in accordance with 808.10 prior to placement of the new markings. Removal of pavement marking material shall be in accordance with 808.10. The pavement surface shall be dry prior to applying pavement traffic markings.

Control points required as a guide for pavement traffic markings shall be spotted with paint for the full length of the road to be marked. Control points along tangent sections shall be spaced at a maximum interval of 100 ft (30 m). Control points along curve sections shall be spaced so as to ensure the accurate location of the pavement traffic markings. The location of control points shall be approved prior to the pavement traffic marking application.

808.04 Longitudinal Markings

All longitudinal lines shall be clearly and sharply delineated, straight and true on tangent, and form a smooth curve where required. Lines shall be square at both ends, without mist, drip or spatter.

A solid line shall be continuous. A broken line shall consist of 10 ft (3 m) line segments with 30 ft (9 m) gaps.

All lines shall be gapped at intersections unless otherwise specified or directed.

The actual repainting limits for no-passing zone markings will be determined by the Engineer.

A new broken line placed over an existing broken line shall laterally match the existing broken line, and the new line segments shall not extend longitudinally more than 10% beyond either end of the existing line segments.

(a) Center Lines

Center lines shall be used to separate lanes of traffic moving in opposite directions. All center line markings shall be yellow in color and 4 in. (100 mm) in width. They shall be placed such that the edge of the marking, nearest to the geometric centerline of the roadway, shall be offset 4 in. (100 mm) from the geometric centerline.

The center line of a multi-lane roadway shall be marked with a double solid line. The two lines forming the double solid line shall be spaced 8 in. (200 mm) apart and shall be equally offset on opposite sides of the geometric centerline.

The center line of a 2-lane, 2-way roadway, where passing is allowed in both directions, shall be marked with a broken line.

The center line of a 2-lane, 2-way roadway, where passing is allowed in one direction only, shall be marked with a double line, consisting of a broken line and a solid line. The broken line and the solid line shall be spaced 8 in. (200 mm) apart and shall be equally offset on opposite sides of the geometric centerline. The solid line shall be offset toward the lane where passing is prohibited. The broken line shall be offset toward the lane where passing is permitted.

(b) Lane Lines

Lane lines shall be used to separate lanes of traffic moving in the same direction. Normal lane line markings shall be white in color and shall be 5 in. (125 mm) wide on freeways, interstates and toll roads, and 4 in. (100 mm) wide on all other roads. They shall be offset 4 in. (100 mm) to the right of longitudinal pavement joints or divisions between traffic lanes. Normal lane lines shall be marked with white broken lines. White solid lines shall be used to mark lane lines only when specified or directed.

(c) Edge Lines

Edge lines shall be used to outline and separate the edge of pavement from the shoulder. Edge line markings shall be 4 in. (100 mm) in width and shall be placed such that the edge of the marking nearest the edge of the pavement shall be offset 4 in. (100 mm) from the edge of the pavement except as otherwise directed. Right edge lines shall be marked with a white solid line and left edge lines shall be marked with a yellow solid line.

(d) Barrier Lines

Barrier lines shall be used as specified or directed. Barrier line markings shall be solid lines of the size and color specified or as directed.

808.05 Transverse Markings

(a) Transverse marking lines shall be used as specified or directed to delineate channelizing lines, stop lines, crosswalk lines, and parking limit lines. The markings shall consist of all necessary lines, of the width specified or directed and shall be in accordance with the MUTCD.

(b) Pavement message marking shall be used as specified or directed for railroad crossing approaches, intersection approaches, crosswalk approaches, handicap parking spaces, and other messages applied to the pavement with pavement marking material. The markings shall consist of all necessary lines, words, and symbols as specified or directed, and shall be in accordance with the MUTCD.

808.06 Curb Markings

Curb markings shall consist of reflectorized paint which shall cover the face and top of the curb. The existing curb and gutter area shall be cleaned of dirt, dust, oil, grease, moisture, curing compound, and unsound layers of other materials before paint is applied to the curb surface.

808.07 Pavement Marking Material Application and Equipment

All double line markings, such as a no passing zone or the center line of an undivided multi-lane roadway, shall be applied in one pass.

Stop lines and crosswalk lines for new or modernized traffic signal installations shall be durable pavement marking material. For this application, preformed plastic may be used on concrete if permitted by manufacturer's recommendations. However, for contract completion dates in winter months when conditions do not permit application of durable markings, traffic paint markings may be substituted with an appropriate unit price adjustment if approved by the Engineer.

(a) Traffic Paint

1. Application

Standard dry and fast dry traffic paint shall be applied only when the pavement temperature is 40°F (5°C) or above. Waterborne traffic paint shall be applied only when the pavement temperature is 50°F (10°C) or above. Standard dry or fast dry traffic paint will only be permitted between October 1 and the following April 30.

The wet film thickness of the traffic paint shall be a minimum of 15 mils (380 µm). Painted lines and markings shall be immediately reflectorized by applying glass beads at a uniform minimum rate of 6 lb/gal. (0.7 kg/L) of traffic paint.

Painted markings on newly constructed surfaces shall receive two applications of paint and glass beads. The second application shall be applied as soon as practical after the first application dries.

2. Equipment

Traffic paint shall be applied with a spray type machine capable of applying the traffic paint under pressure through a nozzle directly onto the pavement. The machine shall be equipped with the following: an air blast device for cleaning the pavement ahead of the painting operation; a guide pointer to keep the machine on an accurate line; at least two spray guns which can be operated individually or simultaneously; paint agitator(s); a control device to maintain uniform flow and application; an automatic device which will provide a broken line of the required length; and an automatic glass bead dispenser which is synchronized with the marking application. When fast drying traffic paint or

waterborne traffic paint is used, the machine shall be capable of heating the paint to application temperatures in accordance with 909.05.

A brush or small hand propelled machine, designed for that purpose, may be used if approved to apply some painted markings.

(b) Durable Pavement Marking Material

Durable pavement marking material consists of thermoplastic, preformed plastic, or epoxy.

1. Thermoplastic

a. Application

Thermoplastic marking material shall be used on asphalt pavements unless otherwise specified or directed. The pavement surface shall be primed with a binder material in accordance with the manufacturer's recommendations. Thermoplastic marking shall be applied in molten form by spray, extrusion, or ribbon type extrusion airless spray when the pavement temperature is 50°F (10°C) or above. The average thickness of each 36 in. (910 mm) length of thermoplastic marking shall be no less than 3/32 in. (2.5 mm) nor more than 3/16 in. (5 m). Immediately following the application of the thermoplastic markings, additional reflectorization shall be provided by applying glass beads to the surface of the molten material at a uniform minimum rate of 6 lb/100 sq ft (2.9 kg/10 m^2) of marking.

b. Equipment

The machine used for the spray application of thermoplastic markings shall consist of a kettle for melting the material and an applicator for applying the markings. All of the equipment required for preheating and applying the material shall maintain a uniform material temperature within the specified limits, without scorching, discoloring or overheating any portion of the material.

The machine shall be equipped with the following: an air blast device for cleaning the pavement ahead of the marking operation; a guide pointer to keep the machine on an accurate line; at least two spray guns which can be operated individually or simultaneously; agitators; a control device to maintain uniform flow and application; an automatic device which will provide a broken line of the required length; and an automatic glass bead dispenser which is synchronized with the marking application.

2. Preformed Plastic

a. Application

The Contractor shall provide the Department with original copies of all necessary current manufacturer's installation manuals prior to beginning installation work. No installation work shall begin prior to the Department's receipt of these manuals. These manuals will become the property of the Department.

Preformed plastic shall be applied when the air temperature is a minimum of 60°F (16°C) and rising, and the pavement temperature is a minimum of 70°F (21°C). Preformed plastic shall not be applied if the ambient temperature is expected to drop to

below 45°F (7°C) within 24 h after application. The pavement surface shall be primed with a binder material in accordance with the manufacturer's recommendations. The pavement surface shall be primed prior to the placement of preformed plastic transverse markings.

If there is a dispute regarding installation, the manufacturer shall provide a properly trained representative to ensure that the installation is performed in accordance with the manufacturer's recommendations.

b. Equipment

The equipment for applying preformed plastic, furnished in rolls, shall be a portable hand-propelled machine capable of carrying and applying at least two rolls of 4 in. (100 mm) to 16 in. (50 mm) widths. The machine shall be equipped with a guide pointer to keep the machine on an accurate line. The machine shall also be equipped with guide rollers and a pressure roller. The pressure roller may be a separate unit. The machine shall feed the marking material from its original carton through the guide rollers and under the pressure roller onto the pavement. The pressure roller shall be a minimum of 2 in. (50 mm) wider than the width of the marking material and shall weigh a minimum of 200 lb (91 kg). The machine shall also be capable of removing the backing paper from the marking material during the application process. Preformed plastic furnished in strip, symbol, or legend form shall be applied with suitable equipment such as hand rollers.

3. Epoxy

a. Application

Epoxy shall be used on portland cement concrete pavement unless otherwise specified or directed. This material shall be applied only when the pavement temperature is 40°F (5°C) or above. The wet film thickness of the epoxy marking material shall be a minimum of 15 mils (380 µm). Immediately following the application of the epoxy markings, additional reflectorization shall be provided by applying glass beads to the surface of the wet marking at a uniform rate of 20 lb/100 sq ft (9.8 kg/10 m^2) of marking.

b. Equipment

The machine used to apply the epoxy marking material shall precisely meter the two components, produce and maintain the necessary mixing head temperature within the required tolerances, all in accordance with the manufacturer's recommendations. The machine shall be equipped with a high pressure water blast device ahead of a high pressure air blast device, both as an integral part of the gun carriage, for cleaning the pavement ahead of the marking application. The machine shall also be equipped with the following: a guide pointer to keep the machine on an accurate line; at least two spray guns which can be operated individually or simultaneously; an automatic device which will provide a broken line of the required length; and automatic glass bead dispensers which is synchronized with the marking application.

808.08 Marking Protection and Maintenance of Traffic

Protection of the traveling public, of the pavement marking crews, and of the pavement markings shall be provided during the marking operation through the use of proper equipment, traffic control devices, safety devices and proper procedures. Traffic

control devices shall be placed in accordance with 107.12. Flaggers shall be provided for traffic control as directed.

(a) Vehicle Signs

Each vehicle in the marking operation shall display the slow moving vehicle emblem when operating at speeds of 25 mph (40 km/h) or less. The slow moving emblems shall be removed when the vehicles are operating at speeds greater than 25 mph (40 km/h). The paint crew signs shall be 24 in. (600 mm) high by 96 in. (2400 mm) wide, with 12 in. (300 mm) series C black letters on an orange encapsulated lens reflective background. Type A and C flashing arrow signs shall be in accordance with 923.04.

(b) Vehicle Warning Lights

All amber flashing warning lights and amber strobe lights mounted on vehicles used in the marking operation shall be in accordance with 801.14(d). All vehicles used in the marking operation shall have a minimum of one flashing amber warning light or amber strobe light which is visible in all directions.

(c) Cones

Cones shall be used to protect marking material which requires more than 60 s drying time. Cones shall remain in place until the marking material is dry or firm enough not to track or deform under traffic. Cones shall be removed as soon as possible and shall never be left in place overnight. Edge lines shall not require protection with cones.

The maximum spacing of cones shall be as follows:

	40 MPH or less	Over 40 MPH
Broken Lines	every line segment	every 5th line segment
Solid Lines	20 ft to 30 ft (6 m to 9 m)	

(d) Front Escort Vehicles

A front escort vehicle shall be used if the marking vehicle extends across the center line while operating. This front escort vehicle shall be equipped with a forward facing paint crew sign, a rear facing slow moving vehicle emblem, and a red flag mounted at least 10 ft (3 m) above the pavement.

(e) Marking Application Vehicles

Marking application vehicles such as edgeliner or centerliner trucks shall have a rear facing type A or type C flashing arrow sign, an amber flashing warning light mounted near the center of the truck bed and an amber strobe light mounted on each rear corner of the truck bed. The amber flashing warning light and the amber strobe lights shall be mounted on retractable supports and shall be operated at a height of 12 ft (3.7 m) above the pavement unless otherwise directed.

(f) Rear Escort Vehicles

If cones are not required, a rear escort vehicle shall follow a marking application vehicle at a distance of 100 to 500 ft (30 to 150 m). If an additional rear escort vehicle is required due to drying time or heavy traffic volume, it shall follow the first rear escort

vehicle at a maximum distance of 1,000 ft (300 m), and may operate in the travel lane or on the paved shoulder.

If cones are required, the cone setting truck shall follow the marking application vehicle and shall be followed by a rear escort vehicle. The cone pick up truck shall be followed by another rear escort vehicle.

All rear escort vehicles shall be equipped with a rear facing type C flashing arrow sign mounted above a rear facing paint crew sign. On two-lane two-way roads, this type C flashing arrow sign shall be operated with the arrowhead turned off. The supply truck may be used as a rear escort vehicle providing it is empty and is equipped with the required traffic control devices.

808.09 Warranty for Durable Pavement Marking Material

Durable pavement marking material shall be warranted against failure resulting from material defects or method of application. The material shall be warranted to retain its color, reflectivity, adherence to the pavement and shall be free of other obvious defects or failures.

All pavement traffic markings which have failed to meet the warranted conditions shall be replaced with no additional payment.

For the terms of the warranty a unit shall be defined as a 1,000 ft (305 m) section of line of specified width in any combination or pattern.

The warranty period shall be 180 days beginning with the last working day for the total contract as defined in the final acceptance letter, but not prior to November 1 of the calendar year in which the last pavement markings were installed. If more than 3% of a unit or 3% of the total of any one intersection or set of transverse markings fails, the failed portion shall be replaced. All pavement markings required to be replaced under the terms of this warranty shall be replaced within 60 days of the notification of failure.

On Federal aid contracts, the 180 day warranty shall apply only to thermoplastic pavement marking material.

808.10 Removal of Pavement Markings

Pavement markings which conflict with revised traffic patterns and may confuse motorists shall be removed immediately before, or immediately following, any change in traffic patterns as directed or approved.

Removal of pavement markings shall be to the fullest extent possible without materially damaging the pavement surface. Pavement marking removal methods shall be sandblasting, steel shot blasting, waterblasting, grinding or other approved mechanical means. Grooving will not be permitted. Grinding will only be permitted when removing thermoplastic or epoxy pavement markings. Painting over existing pavement markings to obliterate them will not be permitted.

When a blast method is used to remove pavement markings, the residue, including sand, dust and marking material, shall be vacuumed concurrently with the blasting

operation or removed by other approved methods. Accumulation of sand, dust or other residual material, which might interfere with drainage or constitute a traffic hazard, will not be permitted.

All damage to the pavement caused by pavement marking removal shall be repaired by approved methods with no additional payment.

808.11 Snowplowable Raised Pavement Markers

Snowplowable raised pavement markers shall be used as supplemental delineation at the locations shown on the plans or as directed.

(a) Surface Preparation

The pavement or bridge deck surface shall be cleaned of dirt, dust, oil, grease, moisture, curing compound, and loose or unsound layers of all materials which would interfere with the proper bonding of the marker to the pavement or bridge deck.

(b) Location

Marker locations shall be accurately laid out and approved prior to the installation operation. Markers shall not be located on surfaces that show visible evidence of cracking, checking, spalling or failure of underlying materials. Markers shall not be located within the intersection of a public road. Any marker location, which falls on any of the restricted areas, shall be moved a longitudinal distance not to exceed 10% of the required marker spacing. If this adjusted location still falls within a restricted area, then that marker location shall be deleted. Marker locations shall be as shown on the plans.

(c) Reflector Color

The color combinations of the reflectors shall be as shown on the plans unless otherwise directed. When replacement prismatic reflectors are specified, such reflectors shall not be ordered until the quantity and color combinations have been determined and approved.

(d) Installation

Marker installation shall be in accordance with the manufacturer's recommendations. The pavement surface temperature and the ambient temperature shall be at least 50°F (10°C). The pavement surface shall be dry at the time of marker installation. The installation slot shall be clean and dry before the adhesive is applied. The slot shall be filled with sufficient adhesive to provide a water tight seal between the marker base and the pavement, and to fill all voids between the marker base and the surfaces of the slot. The marker shall be placed in the slot so that the tips of the snowplow deflecting surfaces are below the pavement surface.

If the pavement surface is newly placed HMA, the pavement shall be allowed to cure for two days prior to installing the markers.

Installation of markers on new concrete pavement or bridge decks or on newly overlaid bridge decks shall not be done until after the pavement or bridge deck is ready to be opened to traffic as specified elsewhere herein.

The number of slots cut in one day shall not exceed the number of markers which will be installed in that day. No slots shall be left open overnight.

(e) Removal of Markers

Markers designated for removal shall be as located on the plans or as otherwise specified or directed. If the pavement surface or bridge deck surface is to be removed, the markers shall be removed prior to any surface removal operation.

The markers shall be removed with a jack hammer or other approved equipment. Care shall be taken so as not to damage the marker base during its removal. The area of the pavement or bridge deck disturbed by the marker removal shall not exceed 3 in. (75 mm) in depth nor 3 in. (75 mm) out from all sides of the marker base. The marker removal operation shall stop if it is determined that excessive damage is occurring to the pavement, bridge deck or marker base.

The resulting holes shall be filled with the appropriate patching material as described herein or as otherwise directed. Concrete pavement which is to be overlaid as part of the contract and HMA pavement shall be patched with HMA intermediate materials. Concrete pavement which is not to be overlaid as part of the contract and concrete bridge decks shall be patched with magnesium phosphate concrete patching material. Overlaid bridge decks and bridge decks which are to be overlaid as part of the contract shall be patched with patching material which is compatible with the deck overlay material. All patching material shall be placed in accordance with the appropriate specifications for the patching material.

Removed markers shall remain the property of the Department unless otherwise specified.

Removed snowplowable raised pavement markers shall be delivered to the District Traffic Division. The markers shall be delivered in 55 gal (210 L) metal containers with lids which may be sealed. The metal containers shall be furnished either by the Contractor or by the District Traffic Division as specified in the contract. Approximately 50 markers shall be placed in each container. Each container shall be labeled as to how many markers it contains.

All metal containers used for delivering removed markers will remain the property of the Department when no longer required for the contract.

(f) Replacement of Prismatic Reflectors

Reflectors designated for replacement shall be as shown on the plans or as otherwise directed. Prior to placement of the new reflector, the castings shall be cleaned of all remaining butyl pad materials. All loose or foreign material shall be satisfactorily removed by sandblasting, wire brush, or other approved mechanical means. Removed reflectors shall be disposed of properly off the project site.

808.12 Method of Measurement

Broken lines, placed or removed, will be measured as 1/4 of the total distance in linear feet (meters) of the broken line pattern after excluding gaps for intersections or other openings. Solid lines will be measured as the total distance in linear feet (meters) of

solid lines placed or removed. The material, type, color, or width of broken or solid lines to be removed will not be considered when measuring such lines for payment.

Transverse marking lines will be measured as the total distance in linear feet (meters) of lines placed or removed. Curb markings will be measured by the linear feet (meters) along the front face of the curb. The "No Parking Any Time" sign will be measured in accordance with 802.11. Pavement message markings will be measured by the total number of each type placed. A railroad crossing pavement message marking shall include the two R's, the X, and the three stop lines per traffic lane. Railroad crossing pavement message markings will be measured by the total number of each marking place. Lane indication arrow pavement message markings will be measured by the number of lane indication arrowheads placed. Removal of pavement message markings will be measured in square yards (square meters) using areas shown in the following table. The material will not be considered when measuring such markings for pavement.

Pavement Message Markings Table

Description	Area
"Ahead"	3.1 SYS (2.6 m2)
Combo Arrow	3.1 SYS (2.6 m2)
"Exit"	2.5 SYS (2.1 m2)
"Left"	2.5 SYS (2.1 m2)
"Only"	2.5 SYS (2.1 m2)
Railroad "R"	0.6 SYS (0.5 m2)
"Right"	3.2 SYS (2.7 m2)
"RXR"	7.7 SYS (6.4 m2)
"School"	3.9 SYS (3.3 m2)
"Stop"	2.6 SYS (2.2 m2)
Straight Arrow	1.4 SYS (1.2 m2)
"Turn"	2.6 SYS (2.2 m2)
Turn Arrow	1.7 SYS (1.4 m2)
"XING"	2.5 SYS (2.1 m2)

Snowplowable raised pavement markers will be measured by the number placed or removed. Prismatic reflectors will be measured by the number furnished and installed. Each 2-way prismatic reflector will be measured as one reflector. No measurement will be made of the adhesive or the hole patching material used in the placement or removal of snowplowable raised pavement markers.

808.13 Basis of Payment

Lines and transverse markings placed will be paid for at the contract unit price per linear foot (meter) for the material, type, color, and width specified. Curb markings will be paid for at the contract unit price per linear foot (meter) for curb painting, of the color specified. The "No Parking Any Time" sign will be paid for in accordance with 808.13. Pavement message markings placed will be paid for at the contract unit price per each, for the material and message specified. Lines and transverse markings removed will be

paid for at the contract unit price per linear foot (meter). Pavement message markings removed will be paid for at the contract unit price per square yard (square meter).

Snowplowable raised pavement markers, furnished and installed, or removed will be paid for at the contract unit price per each. Prismatic reflectors will be paid for at the contract unit price per each. each 2-way prismatic reflector will be paid for as one reflector.

If no pay items are shown in the Schedule of Pay Items for the required permanent pavement markings, a change order will be executed.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Curb Painting, _____ (color)	LFT (m)
Line, _____ (material), _____ (type), _____ (color), _____ (width) in. (mm)	LFT (m)
Line, Removed	LFT (m)
Pavement Message Marking, _____ (material), _____ (message)	EACH
Pavement Message Marking, Remove	SYS (m2)
Prismatic Reflector	EACH
Snowplowable Raised Pavement Marker	EACH
Snowplowable Raised Pavement Marker, Remove	EACH
Transverse Marking, _____ (material), _____ (type), _____ (color), _____ (width) in. (mm)	LFT (m)
Transverse Marking, Remove	LFT (m)

No additional payment will be made for the second application of traffic paint and glass beads as required in 808.07(a)1.

The cost of metal containers for disposal of removed snowplowable raised pavement markers, if furnished by the Contractor, shall be included in the cost of other pay items. The cost of picking up and returning such metal containers, if furnished by the District Traffic Division, shall be included in the cost of other pay items.

The cost of delivering removed and packaged snowplowable raised pavement markers to the designated location shall be included in the cost of transportation of salvageable materials.

The cost of removal of existing prismatic reflectors shall be included in the cost of prismatic reflectors.

Glass beads, binder material for thermoplastic and preformed plastic, adhesive for snowplowable markers, patching material for snowplowable marker removal, pavement cleaning, removal of excess or loose existing pavement marking material where new

pavement markings are being placed in the same locations, and all necessary incidentals shall be included in the cost of the pay items.

SECTION 809 – ITS CONTROLLER CABINETS AND FOUNDATIONS

809.01 Description

This work shall consist of furnishing and installing ITS cabinets and foundations in accordance with 105.03.

MATERIALS

809.02 Materials

Materials shall be in accordance with the following:

ITS Controller Cabinet.....925
Padlock.....925.04(aa)

Materials for ITS cabinet foundations shall be in accordance with 805.02.

CONSTRUCTION REQUIREMENTS

809.03 General

ITS cabinet foundations shall be installed in accordance with 805.13.

A seal of silicone caulking compound shall be placed between each controller cabinet and the concrete foundation after the cabinet placement.

A rubber duct seal shall be used to seal all conduits that enter the bottom of the cabinet.

The input power source to the cabinets shall be 240 volts AC and 60 amps.

One laminated 11 x 17 in. (280 x 430 mm) site drawing shall be included in the data pocket of each cabinet.

809.04 Grounding

All ITS controller cabinets and foundations shall be grounded in accordance with the ITS grounding specification.

809.05 Cabinet Wiring

Wiring within ITS cabinets shall be neatly arranged and ty-wrapped, or enclosed in expandable braided polyester sleeving. All cabinet wiring harnesses shall be neat, firm, routed, and mechanically supported to minimize crosstalk, electrical interference, and to prevent inadvertent pulling. AC power cable shall be routed and bundled separately from shielded control cables: i.e. logic voltage, video cables, RF cables, etc.

All conductors, except for the equipment-grounding conductors, shall be individually labeled at each termination with a unique identifier. All terminal blocks shall be labeled in accordance with the appropriate standard schematic drawings in the plans.

Conductors used in cabinet wiring shall terminate with properly sized captive terminals, spade type terminals, or shall be soldered. All crimp-style connectors shall be applied with a proper tool that prevents opening of the handles until the crimp is completed.

No more than 3 conductors shall be brought to any one terminal. Two flat metal jumpers, straight or U-shaped, may also be placed under a terminal screw. At least 2 full threads of all terminal screws shall be fully engaged when the screw is tightened. No live parts shall extend beyond the barrier.

Connectors, or devices plugging into connectors, shall be provided with positive means to prevent any individual circuit from being broken due to vibration, pull on connecting cable, or some similar disruptive force.

809.06 Field Testing

Cabinets and ITS components shall be field tested in accordance with the field test procedure furnished by the Department and the test results shall be submitted to the ITS Electronics Technician of the Operations Support Division. The Contractor shall record all test readings, in triplicate, on the field test procedure form. The Contactor shall complete, sign, and date the forms before submitting them to the ITS Electronics Technician. All necessary equipment and personnel shall be provided to ensure the tests are safely conducted. The Electronics Technician must be present to witness the tests. A cabinet must pass every test to be accepted. If the cabinet fails, the problem shall be corrected and a new test shall be arranged.

The technician shall be given at least 36 h advance notice of the test.

809.07 Clean-Up

When the installation is completed, all disturbed portions of the construction area shall be cleaned and all excess excavation or other materials shall be disposed of in accordance with 104.05 and 203.10. The site shall be restored to its original conditions.

809.08 Method of Measurement

ITS controller cabinet foundations will be measured per each installed, complete and in place. ITS controller cabinets will be measured by the number of units installed, complete and in place.

809.09 Basis of Payment

ITS controller cabinet foundations will be paid for at the contract price per each. ITS controller cabinets, complete, in place, will be paid for at the contract unit price per each.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
ITS Controller Cabinet	EACH
ITS Controller Cabinet Foundation	EACH

The cost of all cabinet accessories, mounting hardware, anchor bolts, handles, setup and wiring shall be included in the cost of the ITS controller cabinet.

The cost of all grading necessary for installation of the foundations and the final clean-up of the area shall be included in the cost of the ITS controller cabinet foundation.

The cost of padlocks shall be included in the cost of the ITS controller cabinet.