

701

Part 7-INCIDENTAL CONSTRUCTION AND SERVICES

SECTION 701-CEMENT CONCRETE SIDEWALKS, DRIVEWAYS AND MEDIAN PAVEMENT

| | |
|---|------------|
| 701.01-Description | 551 |
| 701.02-Materials..... | 551 |
| 701.03-Equipment | 551 |
| 701.04-Preliminary Work..... | 552 |
| 701.05-Subgrade Preparation | 552 |
| 701.06-Expansion Joints..... | 552 |
| 701.07-Limitations of Mixing..... | 552 |
| 701.08-Mixing and Placing Concrete | 552 |
| 701.09-Finishing | 552 |
| 701.10-Protection and Curing..... | 553 |
| 701.11-Backfilling | 554 |
| 701.12-Final Cleanup..... | 554 |
| 701.13-Method of Measurement | 554 |
| 701.14-Basis of Payment..... | 554 |

SECTION 701-CEMENT CONCRETE SIDEWALKS, DRIVEWAYS AND MEDIAN PAVEMENT

701.01-Description. This work shall consist of constructing Sidewalks, Driveways, and Median Pavement, exclusive of Sidewalks, Driveways, and Median Pavement that are integrally part of structures, of portland cement concrete on a prepared subgrade, in accordance with these Specifications and in reasonably close conformity with the lines, grades, and typical cross sections shown on the Plans or established by the Engineer.

MATERIALS

701.02-Materials. Materials shall meet the requirements of **Sections 604** and **913**, together with the following Subsections of **Division III Materials**:

| <u>Material</u> | <u>Subsection</u> |
|--------------------------------------|-------------------|
| Preformed Joint Filler | 905.01 |
| Drain Pipe, Standard Strength | 914.04 |

Concrete for sidewalks, driveways, and median pavement shall be Class A concrete, meeting all the requirements prescribed in **Section 604**, Concrete Structures.

EQUIPMENT

701.03-Equipment.

(a) Forms.

Forms shall be of wood, metal, or other suitable material and shall extend for the full depth of the concrete. All forms shall be true to line, free from warp, and of sufficient strength to resist the pressure of the concrete without springing. Curved forms of proper radius shall be used on all radial sections and shall be of a design acceptable to the Engineer. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their removal.

(b) Mixing and Finishing Equipment.

Mixers shall meet the requirements of **Subsection 501.04**.

Satisfactory floats, templates, straightedges, edgers, spades, and tamps shall be furnished. Compaction of subgrade shall be accomplished by any type of tamping or rolling equipment that will produce the desired results.

A slip form paver which is capable of producing the required results may be used in lieu of forms.

CONSTRUCTION REQUIREMENTS

701.04-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction shall be performed in accordance with the provisions of **Sections 201, 202, 203, and 205**, respectively.

701.05-Subgrade Preparation. Subgrade preparation for sidewalks, driveways, and median pavement shall be made to the required depth and to a width that will permit the installation and bracing of the forms. The subgrade shall be shaped and compacted to a firm, even surface in reasonably close conformity with the grade and cross section shown on the Plans. All soft and yielding material shall be removed and replaced with acceptable material, which shall then be compacted as directed.

701.06-Expansion Joints. Unless otherwise indicated on the Plans or directed by the Engineer, premolded expansion joint filler, 1 in.(25 mm) in thickness, shall be placed at the locations and in line with expansion joints in the adjoining pavement, gutter or curb. All premolded expansion joint filler shall be cut to full width or length of the proposed construction and shall extend to within 1 in.(25 mm) of the top or finished surface. All longitudinal expansion joints shall be placed as indicated on the Plans or as directed by the Engineer. All expansion joints shall be true, even, and present a satisfactory appearance.

Construction joints shall be formed around all appurtenances, such as manholes, utility poles, etc., extending into and through the sidewalk or median area. Premolded expansion joint filler, 1 in.(25 mm) thick, shall be installed in these joints. Expansion joint filler of the thickness indicated shall be installed between concrete sidewalks and any fixed structure, such as a building or bridge. One inch(25 mm) thick expansion joint filler shall be installed between concrete curb and median pavement and, unless otherwise specified, between concrete curb and sidewalk. This expansion joint material shall extend for the full depth of the walk or median pavement.

701.07-Limitations of Mixing. Limitations on the mixing of concrete shall be as prescribed in **Subsection 501.11**.

701.08-Mixing and Placing Concrete. Concrete shall be mixed in accordance with the provisions of **Subsection 604.14**. Placing concrete shall be performed as provided for under **Subsection 501.12**, except that mechanical spreaders will not be required. Immediately before placing the concrete, the subgrade shall be thoroughly wetted, and the forms given a coating of light oil. The forms shall be thoroughly cleaned and oiled each time before using.

701.09-Finishing. The concrete shall be struck-off with a transverse template resting upon the side forms. After the concrete has been struck-off

to the required cross section, it shall be finished with floats and straightedges until the required surface requirements have been obtained.

When the surface of the concrete is free from water and just before the concrete obtains its initial set, it shall be finished and swept lightly with a broom in order to produce a sandy texture. The longitudinal surface variations shall be not more than 1/4 in.(6 mm) under a 12 ft.(3.6 m) straightedge, nor more than 1/8 in.(3 mm) on a 5 ft.(1.5 m) transverse section. The surface of the concrete shall be so finished as to drain completely at all times.

The edges of the sidewalks, driveways and median pavement shall be carefully finished and rounded with an edging tool having a radius 1/2 in.(13 mm).

The surface of sidewalks shall be divided into blocks by use of a grooving tool. The grooves shall be spaced approximately 5 ft.(3 m) apart and the blocks shall be rectangular unless otherwise ordered by the Engineer. The grooves shall be cut to a depth of not less than 1 inch. The edges of the grooves shall be edged with an edging tool having a radius of 1/4 in.(6 mm). Grooves shall be placed in median pavement in line with corresponding joints in adjoining construction or as directed by the Engineer.

Unless otherwise indicated on the Plans, marks or grooves shall be placed at right angles to the center-line of driveways and approximately 8 in.(200 mm) apart. These markings shall be between 1/8 and 1/4 in.(3 to 6 mm) in depth and shall be made with a suitable marking tool. A grooving tool, 6 to 8 in.(150 to 200 mm) in width, with multiple grooves for grooving alternate strips 8 in.(200 mm) apart, may be used. Any irregularities caused by the edges of the marking tool shall be removed by the use of a wetted brush or wooden float. All marking edges shall be rounded satisfactorily.

Grooves shall not be placed in the surface of sidewalks or driveways reinforced for beam action where the full thickness of concrete is required for strength.

The edges of the concrete at expansion joints shall be rounded with an edging tool having a radius of 1/4 in.(6 mm). All marks caused by edging shall be removed. The top and ends of expansion joint material shall be cleaned of all concrete, and the expansion joint material shall be so trimmed as to be slightly below the surface of the concrete.

701.10-Protection and Curing. Forms may be removed at any time that removal will not damage the concrete. No pressure shall be exerted upon the concrete in removing forms.

Curing and protection during cold weather shall be performed as provided for under **Subsection 501.18** of these Specifications.

Pedestrians will not be allowed upon concrete sidewalks, driveways, or medians until 12 hours after finishing concrete, and no vehicles or loads shall be permitted on any sidewalk, driveway, or median until the Engineer has determined that the concrete has attained sufficient strength for such loads.

The Contractor shall construct and place such barricades and protection devices as are necessary to keep pedestrians and other traffic off the sidewalk, driveway, or median.

701

Any sidewalk, driveway, or paved median damaged prior to final acceptance of the project shall be repaired, at the Contractor's expense, by removing concrete within groove limits and replacing it with concrete of the type and finish in the original construction.

701.11-Backfilling. Immediately after removing the side forms, the spaces along the edges of sidewalk or driveway shall be filled with suitable material. This material shall be placed in layers not exceeding 4 in.(100 mm) in loose thickness, and compacted until firm and stable.

701.12-Final Cleanup. Final Cleanup shall be performed in accordance with the requirements of **Subsection 104.11.**

COMPENSATION

701.13-Method of Measurement. Concrete Sidewalks and Concrete Driveways will be measured by the s.f. (m^2), complete in place. The area shall be obtained by surface measurements. Where standard widths are constructed, the measurements shall not exceed the standard widths shown on the Plans, unless approved in writing by the Engineer. Concrete Sidewalks of each thickness, and Concrete Driveways, will be measured separately. Concrete Median Pavement will be measured by the c.y. (m^3), complete in place. The volume shall be obtained from the specified thickness shown on the Plans and surface measurements for width and length.

No measurement for payment will be made for preparing the subgrade, for backfill, expansion joint materials or drain pipe, unless otherwise indicated on the Plans, as these are necessary parts of the construction.

701.14-Basis of Payment. The accepted quantities of Concrete Sidewalk of each thickness and Concrete Driveway will be paid for at the contract unit price per s.f. (m^2) for the respective items, complete in place. The accepted quantities of Concrete Median Pavement will be paid for at the contract unit price per c.y. (m^3), complete in place.

**SECTION 702-CEMENT CONCRETE CURB,
GUTTER, AND COMBINED CURB AND GUTTER**

702.01-Description 556
702.02-Materials..... 556
702.03-Equipment 556
702.04-Preliminary Work..... 557
702.05-Subgrade Preparation 557
702.06-Expansion Joints 557
702.07-Limitations on Mixing 557
702.08-Mixing, Placing, and Finishing Concrete 557
702.09-Protection and Curing..... 558
702.10-Backfilling 558
702.11-Final Cleanup..... 558
702.12-Method of Measurement..... 558
702.13-Basis of Payment..... 559

SECTION 702-CEMENT CONCRETE CURB, GUTTER AND COMBINED CURB AND GUTTER

702.01-Description. This work shall consist of Curb, Gutter, or Combined Curb and Gutter constructed of portland cement concrete in accordance with these Specifications, at the locations and in reasonably close conformity with the lines, grades and dimensions shown on the Plans, or established by the Engineer.

MATERIALS

702.02-Materials. Materials shall meet the applicable requirements of **Sections 604** and **913**, together with the following Subsections of Division III-Materials:

| <u>Material</u> | <u>Subsection</u> |
|--------------------------------------|--------------------------|
| Preformed Joint Filler | 905.01 |
| Drain Pipe, Standard Strength | 914.04 |

Concrete for curb, gutter and combined curb and gutter shall be Class A concrete, meeting all the requirements prescribed in **Section 604**, Concrete Structures, with the following exception when placed with a curb extruding machine; Slump shall range from 0 to 3 in.(0 to 75 mm)

The water and percentages of fine and coarse aggregate may be adjusted within the limits specified(fine aggregate may range from 40 to 65%) to permit satisfactory placement.

Compressive strength test specimens may be made by the vibratory method in accordance with AASHTO T 23 or other approved methods.

EQUIPMENT

702.03-Equipment.

(a) Forms.

Forms, except the templates between 10 ft.(3 m) sections, may be either wood or metal meeting the requirements prescribed in **Subsection 701.03(a)**. The templates shall be 1/8 in.(3 mm) thick metal, of the same width as that of the curb, gutter, or combination curb and gutter, and not less than 1/4 in.(6 mm) more in depth than the respective depth of the type curb and gutter being constructed. The templates shall have lugs, or other devices to hold them in position during placing of the concrete and shall be of such design as to permit removal without causing damage to the concrete. For gutters, a strike-off template of the form and shape of the gutter shall be used to shape the top surface of the gutter.

(b) Compaction Equipment.

Compaction of subgrade shall be accomplished by any type of tamping or rolling equipment that will produce the desired results.

(c) **Mixing and Finishing Equipment.**

Mixers shall meet the requirements of **Subsection 501.04(b)**. A curb machine that will place the concrete in a satisfactory manner may be used when approved by the Engineer. Finishing equipment shall include satisfactory floats, edgers, spades and tamps.

CONSTRUCTION REQUIREMENTS

702.04-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction shall be performed in accordance with provisions of **Sections 201, 202, 203 and 205**, respectively, of these Specifications.

702.05-Subgrade Preparation. Subgrade preparation for curb, gutter, and combined curb and gutter shall be made to the required depth, and to a width that will permit the installation and bracing of the forms. The subgrade shall be shaped and compacted to a firm, even surface, in reasonably close conformity with the grade and section shown on the Plans. All soft and yielding material shall be removed and replaced with acceptable material that shall then be compacted as directed.

702.06-Expansion Joints. Expansion joints shall be formed at the intervals and locations shown on the Plans, using preformed filler 1 in.(25 mm) thick, unless otherwise specified. They shall be placed in line with corresponding expansion joints in adjoining pavement or other construction. Joint filler shall be cut to the full cross section of the curb, gutter, or curb and gutter.

702.07-Limitations on Mixing. Limitations on the mixing of concrete shall be as prescribed in **Subsection 501.11**.

702.08-Mixing, Placing, and Finishing Concrete. Concrete shall be mixed in accordance with the requirements of **Subsection 604.14**.

Immediately before placing the concrete, the subgrade shall be thoroughly wetted, and the forms given a coating of light oil. The forms shall be thoroughly cleaned and oiled each time before using. Placing concrete shall be performed as provided for under **Subsection 501.12**, except that the mechanical spreader will not be required.

The concrete shall be placed immediately after mixing; the edges, sides, or faces, shall be thoroughly spaded and vibrated sufficiently to consolidate the concrete thoroughly and bring the mortar to the surface, after which the surface shall be finished smooth and even by means of a wooden float.

Concrete curb, gutter, or combined curb and gutter, shall be constructed reasonably true to line, grade and cross section, and, unless otherwise specified on the Plans, in sections having uniform lengths of 10 ft.(3 m). The length of these sections may be reduced where necessary for closures,

but no section less than 6 ft.(1.8 m) will be permitted. The templates shall be set carefully before the placing of the concrete and allowed to remain in place until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place. The forms on the face of all curbs shall be removed as soon as the concrete will hold its shape and the surface then floated with a wooden float to a smooth and even finish. No plastering will be permitted. Unless otherwise specified, the top edges of the curb and the edge of the gutter shall be rounded to a radius of 3/4 in.(19 mm), and the edges on each side of templates and expansion joint material shall be finished with an edging tool with a radius of not over 1/4 in.(6 mm) and then all lines or marks shall be removed with a wet brush. The back of curbs shall be finished not less than 3 in.(75 mm) below the top of backfill against the curb. Any exposed surface or surfaces against which some rigid type of construction is to be made shall be left smooth and uniform so as to permit free movement of the curb, gutter or combined curb and gutter.

All tool marks shall be removed with a wetted brush or wooden float, and the finished surface shall present a uniform and pleasing appearance.

When the use of curb machines is permitted, finishing shall be performed as specified above except that contraction joints may be sawed a minimum depth of 1/4 in. (6 mm) the thickness of the section at intervals not less than 6 ft.(1.8 m) nor more than 10 ft.(3 m) in lieu of constructing the curbs in sections.

Weep holes or drainage openings shall be placed through curbs as indicated on the Plans or as directed by the Engineer, and coarse aggregate shall be placed behind each opening as needed.

702.09-Protection and Curing. Immediately after finishing the concrete, protection and curing shall be performed in accordance with the provisions of **Subsection 501.18** of these Specifications.

The Contractor shall protect the curb, gutter, and combined curb and gutter until finally accepted. Any concrete that is damaged during that period shall be repaired by removing and reconstructing each 10 ft.(3 m) section that has been damaged. This reconstruction shall be at the Contractor's expense.

702.10-Backfilling. Immediately after the concrete has set sufficiently, and the forms have been removed, the space back of the curb or combined curb and gutter shall be filled with suitable material. This material shall be placed in layers not exceeding 4 in.(100 mm) in loose thickness, and compacted until firm and stable.

702.11-Final Cleanup. Final Cleanup shall be performed in accordance with the requirements of **Subsection 104.11**.

COMPENSATION

702.12-Method of Measurement. Concrete Curb, Concrete Gutter, and Concrete Combined Curb and Gutter will be measured for payment by the c.y. (m^3), complete in place. The volume, per linear foot(linear meter) of length, shall be obtained from the dimensions shown on the Plans. Linear

measurements will be surface measurements taken along the center of gravity of the section.

No measurement for payment will be made for preparing the subgrade, for backfill, for expansion joint materials or drain pipe, unless otherwise indicated on the Plans.

No measurement for payment will be made under this section for curb integral with concrete pavement or concrete base unless otherwise specified on the Plans or in the Contract.

702.13-Basis of Payment. The accepted quantities of Concrete Curb, Concrete Gutter, or Concrete Combined Curb and Gutter will be paid for at the contract unit price per c.y. (m³) for the respective items.

703

**SECTION 703-CEMENT CONCRETE DITCH
PAVING**

| | |
|---|------------|
| 703.01-Description | 561 |
| 703.02-Materials..... | 561 |
| 703.03-Equipment..... | 561 |
| 703.04-Preliminary Work | 561 |
| 703.05-Subgrade Preparation..... | 561 |
| 703.06-Joints..... | 562 |
| 703.07-Limitations on Mixing..... | 562 |
| 703.08-Mixing, Placing, and Finishing Concrete | 562 |
| 703.09-Protection and Curing..... | 562 |
| 703.10-Backfilling | 562 |
| 703.11-Final Cleanup..... | 562 |
| 703.12-Method of Measurement..... | 562 |
| 703.13-Basis of Payment..... | 563 |

SECTION 703-PORTLAND CEMENT CONCRETE DITCH PAVING

703.01-Description. Portland Cement Concrete Ditch Paving shall consist of the construction of paved ditches on a prepared subgrade. The pavement shall be constructed to the specified thickness and within reasonably close conformity to the lines, grades, and cross sections indicated on the Plans or as directed by the Engineer, and in conformity with the requirements and provisions set out in these Specifications.

MATERIALS

703.02-Materials. Materials used in this construction shall meet the applicable requirements of **Section 604**, Concrete Structures.

Concrete for Portland cement concrete ditch paving shall be Class A concrete, meeting all the requirements prescribed in **Section 604**.

EQUIPMENT

703.03-Equipment.

(a) Forms.

Forms may be either wood or metal, meeting the requirements prescribed in **Subsection 701.03(a)**. A strikeoff template of the form and shape of the ditch section shall be used to shape the top surface of the paved ditch.

(b) Compaction Equipment.

Compaction of subgrade shall be accomplished by any type of tamping or rolling equipment that will produce the required compaction and shape.

(c) Mixing and Finishing Equipment.

Mixers shall meet the requirements of **Subsection 501.04(b)**. Mechanical ditch paving machines may be used when approved by the Engineer.

Finishing equipment shall include satisfactory floats, edgers, spades, and tamps.

CONSTRUCTION REQUIREMENTS

703.04-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction shall be performed in accordance with the provisions of **Sections 201, 202, 203, and 205**, respectively, of these Specifications.

703.05-Subgrade Preparation. Subgrade preparation for ditch paving shall be made to the required depth, and to a width that will permit the

703

installation and bracing of forms. The subgrade shall be shaped and compacted to a firm, even surface, in reasonably close conformity with the grade and section shown on the Plans or as directed by the Engineer. All soft and yielding material shall be removed and replaced with acceptable material, which shall then be compacted as directed.

703.06-Joints. Joints shall be formed at the intervals and locations shown on the Plans. Joint filler for expansion joints shall be cut to the full depth of the ditch pavement.

703.07-Limitations on Mixing.. Limitations on the mixing of concrete shall be as prescribed in **Subsection 501.11.**

703.08-Mixing, Placing, and Finishing Concrete. Concrete shall be mixed in accordance with the requirements of **Subsection 604.14.**

Preparations before placing concrete shall be done in accordance with **Subsection 701.08.**

The concrete shall be placed immediately after mixing; the edges shall be spaded and the concrete thoroughly consolidated, after which the surface shall be finished smooth and even by means of a wooden float.

The edges of the paved ditch shall be rounded to a radius of ½ in.(13 mm), and edges along expansion and contraction joints shall be finished with an edging tool with a radius of not over ¼ in.(6 mm) and then all edging tool marks removed with a float and brush.

703.09-Protection and Curing. Immediately after finishing the concrete, it shall be cured as specified under **Subsection 501.18.**

The Contractor shall protect the ditch paving until final acceptance of the project. Any concrete that is damaged prior to acceptance shall be repaired by removing and reconstructing the damaged sections. Such reconstruction shall be at the Contractor's expense.

703.10-Backfilling. Immediately after the concrete has set sufficiently, and the forms have been removed, the spaces on each side of the ditch paving shall be filled with suitable material and thoroughly compacted; or when sod is specified, it shall be laid in accordance with the provisions of **Section 803.**

703.11-Final Cleanup. Final cleanup shall be performed in accordance with the requirements of **Subsection 104.11.**

COMPENSATION

703.12-Method of Measurement. Portland Cement Concrete Ditch Paving will be measured for payment by the c.y.(m³), complete in place. The volume per linear foot(meter) of length shall be obtained from the dimensions shown on the Plans. Linear measurements will be surface measurements made along the center-line of the paved ditch.

No measurement for payment will be made for preparing the subgrade, for backfill, or for expansion joint materials, unless otherwise indicated on the Plans.

703.13-Basis of Payment. The accepted quantities of Portland Cement Concrete Ditch Paving will be paid for at the contract unit price per c.y.(m³).

705

SECTION 705-GUARDRAIL

705.01-Description 565
705.02-Materials..... 565
705.03-Equipment..... 565
705.04-Preliminary Work 565
705.05-Posts..... 565
705.06-Installation of Posts 566
705.07-Erection 567
705.08-Final Cleanup..... 567
705.09-Method of Measurement..... 567
705.10-Basis of Payment..... 567

SECTION 705-GUARDRAIL

705.01-Description. This work shall consist of furnishing and erecting Guardrail, and the construction of anchor blocks and approach ends, of the specified kind and dimensions, in accordance with these Specifications, and in reasonably close conformity with the lines, grades and at the locations shown on the Plans, or as directed by the Engineer.

Guardrail shall include appurtenant materials and work in making connections with other Guardrail or structures, as may be required to complete the construction as indicated on the Plans.

MATERIALS

705.02-Materials. Materials used in the construction of Guardrail, in addition to the general requirements of these Specifications, shall conform, unless otherwise stipulated, to the following Subsections:

| <u>Material</u> | <u>Subsection</u> |
|-----------------------------|-------------------|
| Metal Beam Guardrail | 909.05 |
| Guardrail Posts | 909.07 |
| Guardrail Hardware | 909.08 |

Portland Cement Concrete shall be Class A, and shall be manufactured, placed, finished and cured in accordance with the applicable requirements of **Section 604**.

All guardrail safety End Treatment systems shall require certification from the supplier that the device is an NCHRP 350 approved product, documented in an acceptance letter from FHWA. The acceptance letter stating that the proposed device complies with NCHRP 350, for the appropriate test level, shall be attached to the certification. In addition, detailed shop drawings for the NCHRP 350 approved devices shall be submitted to the Engineer and shall be on-site during installation.

EQUIPMENT

705.03-Equipment. All equipment necessary for the satisfactory performance of this work shall be on hand and approved by the Engineer before construction will be permitted to begin.

CONSTRUCTION REQUIREMENTS

705.04-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction shall be performed in accordance with the provisions of **Sections 201, 202, 203, and 205**, respectively.

705.05-Posts. All posts shall be the shape, size and dimensions shown on the Plans, and/or approved Shop Drawings and shall be set reasonably true to the lines and grades shown on the Plans, or established by the Engineer.

705.06-Installation of Posts. Before beginning any excavations or driving any guardrail post, the Contractor shall determine the location of any underground electrical lines, drainage, or utility lines in the vicinity and shall conduct his work in such a manner as to avoid damage to them. Holes shall be dug or drilled to the depth indicated on the Plans, and/or approved Shop Drawings; or posts may be driven by approved methods and equipment, provided the posts are erected in the proper position and are free of distortion and burring or any other damage.

All post holes that are dug or drilled shall be of such size as will permit proper setting of the posts, and allow sufficient room for backfilling and tamping.

When solid rock is encountered while drilling post holes.

- Within 18 in. (460mm) of the ground surface, an oversized or elongated hole shall be drilled 24 in. (610mm) into the rock. The post shall be set at the roadside edge of the hole and the hole should be backfilled with the cutting spoils. If using wooden posts the oversized hole shall be a single hole 23 in. (580mm) in diameter or three overlapping holes 10 in. (250mm) in diameter to a length of 23 inches. For steel posts, the oversized hole shall be a single hole, 20 in. (530mm) in diameter or three overlapping holes 8 in. (203mm) in diameter to a length of 20 inches.
- Below 18 in. (460mm) of the ground surface hole shall be drilled 12 in. (300mm) into the rock or to the specified depth in Plans. The holes shall be 8 in. diameter for steel posts, and 12 in. diameter for wood posts.
- When installing end terminals using tubes, posts 1 and 2 will be installed to full depth or a minimum of 36 in. into the solid rock. The holes around the steel tube shall be backfilled with the cutting spoils.
- See approved shop drawings for additional information concerning post depth, and size of holes.

Holes shall be backfilled with selected earth or other suitable materials in layers not to exceed 4 in. (100 mm) in thickness and each layer shall be thoroughly tamped. When backfilling and tamping is completed, the posts or anchors shall be held securely in place.

Posts for metal divider guardrail on bridges shall be bolted to the structure as detailed on the Plans. The anchor bolts shall be set to proper location and elevation, with templates, and carefully checked after the median is placed, and before the concrete has set.

Anchor bolts for metal divider guardrail, to be placed on a previously constructed bridge, shall be set by drilling holes in proper locations and anchoring the bolts as detailed on the Plans.

Any damaged coating on galvanized steel posts shall be repaired in accordance with the provisions of **Subsection 713.04(b)** or the posts replaced, at the Engineer's direction, at no cost to the Department.

705.07-Erection. All guardrail anchors shall be set and attachments made and placed as indicated on the Plans, and/or approved Shop Drawings, or as directed by the Engineer. Guardrail installed on new alignments is to be complete in place before the mainline roadway is opened to traffic unless otherwise directed by the Engineer. On roadways open to traffic, each section of guardrail shall be installed complete in place including end sections in a continuous operation.

All bolts or clips used for fastening the guardrail or fittings to the posts shall be drawn up tightly. End bolts shall have sufficient length to extend at least 1/4 in.(6 mm) through and beyond the full nut, except where such extension might interfere with or endanger traffic, in which case, the bolt shall be cut off flush with the nut.

All railings shall be erected, drawn, and adjusted so that the longitudinal tension will be uniform throughout the entire length of the rail.

Metal Deep Beam Single Guardrail and Protective Guardrail at Bridge Ends that are installed on a curve with a radius of 150 ft.(45 m) or less shall be shop curved.

705.08-Final Cleanup. Final cleanup shall be performed as prescribed in **Subsection 104.11.**

COMPENSATION

705.09-Method of Measurement. Guardrail of the various classes and dimensions will be measured in accordance with the Plans.

Terminal Anchors of the various types will be measured for payment by the unit within the limits shown on the plans.

No measurement for payment will be made for projections or anchors beyond the end post, except as noted.

Furnishing and placing anchor bolts and/or devices for guardrail posts on bridges will be considered incidental to the construction and the costs thereof will be included in the price bid for other items of construction.

No measurement for payment will be made for excavation or backfilling performed in connection with this construction.

705.10-Basis of Payment. Guardrail of the various classes and Guardrail End Terminals of the various types will be paid for at the contract unit price per linear foot(meter) and per each, respectively, as indicated on the Plans for each class and type. No payment will be made for a section of guardrail, including end terminals, until it is complete in place. Payment shall be full compensation for all posts, blocks, rail elements, terminal sections, fittings, hardware, labor and equipment, and all incidentals necessary to complete the work. When no contract unit price has been established for Shop Curved Metal Deep Beam Single Guardrail, payment will be made at a rate equal to 1.5 times the contract unit price for Metal Deep Beam Single Guardrail with corresponding post spacing. When no

705

unit price has been established for Shop Curved Protective Guardrail at Bridge Ends, payment will be made at a rate equal to 1.25 times the contract unit price of Protective Guardrail at Bridge Ends.

No additional payment will be made for shop curving the guardrail in the Guardrail End Terminal units.

**SECTION 706-GUARDRAIL ADJUSTED,
REMOVED AND RESET**

706.01-Description 570
706.02-Materials..... 570
706.03-Equipment 570
706.04-Preliminary Work..... 571
706.05-Dismantling or Removing Guardrail 571
706.06-Installation of Posts 571
706.07-Erection 571
706.08-Guardrail Adjustment..... 571
706.09-Final Cleanup..... 571
706.10-Method of Measurement 572
706.11-Basis of Payment..... 572

SECTION 706-GUARDRAIL ADJUSTED, REMOVED AND RESET

706.01-Description. Guardrail Adjusted or Removed and Reset shall consist of dismantling, removing, salvaging, resetting, or adjusting existing guardrail, as indicated on the Plans or as directed by the Engineer. Such guardrail shall be constructed at the locations and in reasonably close conformity with the lines and grades shown on the Plans or established by the Engineer, and in accordance with these Specifications. The work shall include the furnishing of all necessary hardware, anchors and other appurtenances required to replace those that are not suitable for reuse.

Posts Furnished and Guardrail Furnished shall consist of furnishing and setting guardrail and posts that replace rail and posts that are unsuitable for resetting, as shown on the Plans or as directed by the Engineer. Guardrail removed and reset shall comply with current standards as shown on the Department's standard drawings, and/or approved shop drawings, for that type of installation.

MATERIALS

706.02-Materials. Materials used in this work, in addition to the general requirements of these Specifications, shall conform to the requirements of the following Subsection:

| <u>Material</u> | <u>Subsection</u> |
|------------------------|-------------------|
| Guardrail Posts | 909.07 |

All materials that can be reused, shall be removed, dismantled, reshaped, repaired and reset.

Posts, rails, cables, wire, metal sheets or plates, etc., for the reset rail shall be salvaged material, but the Contractor shall furnish whatever additional bolts, clips, and other appurtenances of the kind and quality in the original Guardrail as may be required to complete the Guardrail.

Posts, rail and hardware furnished and set shall be of the size and type used in the original guardrail, or as shown on the Plans, and/or approved Shop Drawings and shall meet the requirements of **Subsections 909.05, 909.07 and 909.08.**

EQUIPMENT

706.03-Equipment. All equipment necessary for the satisfactory performance of this work shall be on hand and approved by the Engineer before construction will be permitted to begin.

CONSTRUCTION REQUIREMENTS

706.04-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction shall be performed in accordance with the provisions of Sections 201, 202, 203, and 205, respectively.

706.05-Dismantling or Removing Guardrail. Railings, anchors, fittings, and any other material suitable for reuse shall be carefully dismantled and detached from the posts, and neatly stored and protected from damage.

The Contractor shall not remove any sections of existing guardrail until the Engineer concurs in the necessity of removal due to construction requirements and the appropriate warning devices are installed. The proposed guardrail, including any anchor system, shall be installed promptly to minimize traffic exposure to any hazard.

All posts shall be excavated or pulled in such a manner that will not damage the posts for further use.

All salvaged material shall be inventoried, cleaned, and stored until it is reset.

The Contractor shall replace, at his own expense, any material of the type and kind damaged or lost, on account of carelessness, negligence, or failure to properly protect the material and conduct the construction.

Any broken posts or stubs shall be removed and disposed of as directed by the Engineer.

706.06-Installation of Posts. This work shall be performed in accordance with the requirements of Subsection 705.06.

Posts to be reused will be so designated by the Engineer.

706.07-Erection. All posts and guardrail to be reset shall be thoroughly cleaned.

Posts shall be spaced as originally spaced, unless otherwise shown on the Plans. They shall be set vertically, and to the depth shown on the Plans or as established by the Engineer.

All other details of erection shall conform with the requirements of Subsection 705.07.

706.08-Guardrail Adjustment. Guardrail adjustment or realignment shall be as detailed on the Plans and be performed in accordance with the applicable requirements of these Specifications.

Realigned guardrail shall be defined as sections of guardrail that may be realigned without removal or disassembly and are not out of line horizontally ± 6 in.(150 mm) or vertically ± 2 in.(50 mm). Adjusted guardrail is guardrail that may be repositioned by the vertical adjustment of the block. Resetting guardrail shall be defined as entire sections of guardrail that require removal as directed by the Engineer.

706.09-Final Cleanup. Final Cleanup shall be performed as prescribed in Subsection 104.11.

COMPENSATION

706.10-Method of Measurement. Guardrail Removed, Guardrail Reset, and Guardrail Adjustment will be measured for payment by the linear foot(meter) along the center-line of the guardrail, and from center of end post to center of end post.

Guardrail Furnished will be measured by the linear foot(meter) along the center-line of the rail before installations.

Posts Furnished will be measured by the individual unit.

End terminals, in accordance with **Subsections 705.09** and **705.10**, respectively will be measured and paid for.

No measurement for payment will be made for projections or end terminals beyond the end post.

No measurement for payment will be made for excavation or backfilling performed in connection with this construction.

706.11-Basis of Payment. The accepted quantities of Guardrail Adjustment, Guardrail Removed, and Guardrail Reset will be paid for at the contract unit price per linear foot(meter), which price shall include all additional bolts, clips, and other incidentals required to complete the work.

The accepted quantities of Posts Furnished and Guardrail Furnished will be paid for at the contract unit price for these items, complete in place.

SECTION 707-FENCES

707.01-Description 574
707.02-Materials..... 574
707.03-Equipment 574
707.04-Preliminary Work..... 574
707.05-Setting Posts and Backfilling 575
707.06-Erecting Fence..... 575
707.07-Final Finishing and Cleanup 576
707.08-Method of Measurement 576
707.09-Basis of Payment..... 577

SECTION 707-FENCES

707.01-Description. This work shall consist of the construction of fences, gates, and water crossings, in accordance with these Specifications, at the locations and in reasonably close conformity with the lines, grades, and dimensions shown on the Plans or as directed by the Engineer.

MATERIALS

707.02-Materials. Materials used in the work shall be of the kind, size, and type specified on the Plans, and shall include all necessary posts, fittings, and appurtenances.

The materials used shall conform to the following Sections and Subsections:

| <u>Material</u> | <u>Section or Subsection</u> |
|-----------------------------------|------------------------------|
| Stock Fence | 909.01 |
| Portland Cement Concrete, Class A | 604 |
| Chain-Link Fence | 909.02 |
| Fence Gates | 909.03 |
| Water Gates and Water Crossings | 909.04 |

All galvanized material that is damaged will be rejected, or may, with the approval of the Engineer, be repaired as specified under **Subsection 713.04(b)** of these Specifications.

EQUIPMENT

707.03-Equipment. All equipment necessary for the satisfactory performance of the work shall be on hand and approved by the Engineer before construction will be permitted to begin.

CONSTRUCTION REQUIREMENTS

707.04-Preliminary Work. Before beginning construction or placing of fences, all necessary Clearing and Grubbing and Removal of Structures and Obstructions shall be performed in accordance with **Sections 201** and **202**, respectively. Clearing for fence construction shall not extend beyond the rights-of-way line. Living trees and shrubs 1 ft.(300 mm) or more each side of the fence line shall remain undisturbed unless otherwise directed by the Engineer. The location of the fence shall be 1 ft.(300 mm) inside the right-of-way unless otherwise shown on the plans. Any rock protruding above the ground surface and in the line of fence shall be removed to ground surface.

Fences shall be turned in at drainage structures, cattle passes, and bridges where directed by the engineer so as to abut wingwalls and/or abutments.

The Contractor shall give the affected property owners two weeks notice prior to cutting existing fences. The Contractor shall be required to install access control fences prior to cutting existing fences in areas utilized by domestic livestock or other areas as directed by the Engineer.

707.05-Setting Posts and Backfilling. Line posts for stock fence shall be set at intervals not to exceed 10 ft.(3 m). Braced line posts shall be erected at intervals of 330 ft.(100 m) between end and/or corner posts, and when necessary due to terrain features, additional braced line posts shall be installed at locations designated by the Engineer. The interval between posts shall be measured parallel to the bottom of the fabric of the proposed fence and in line of fence from center to center of post.

Posts for chain-link fence shall be set at intervals not to exceed 10 ft.(3 m). The intervals between posts shall be measured as provided above.

Posts indicated by the Plans to be set in concrete shall be installed in dug or drilled holes of the size and to the depth indicated on the Plans or directed by the Engineer. Concrete for embedment of posts and for anchors shall be Class A, and shall meet the requirements of **Section 604**. The concrete embedment and anchors shall be crowned at the top to shed water. Posts not requiring concrete embedment may be driven to the required depth by approved methods if ground conditions permit, or they shall be installed in holes dug or drilled to the specified depth and of such size as will allow sufficient room for proper backfilling. When solid rock is encountered, posts shall be installed by drilling the rock to the required depth and grouting the post therein with portland cement grout composed of one part cement to three parts sand.

Post holes for posts not requiring concrete embedment shall be backfilled with selected earth or other approved material. All backfilling shall be performed in layers not exceeding 6 in.(150 mm) and each layer shall be thoroughly tamped. When backfilling and tamping is completed, the posts and anchors shall be held securely in proper position.

Pull shall not be applied to posts set in concrete until the concrete has cured a minimum of 72 hours.

707.06-Erecting Fence. At certain locations along the rights-of-way, the Contractor will be required to construct chain-link fence or stock fence prior to the removal of existing fences when directed by the Engineer.

When fences are constructed 1 foot inside the rights-of-way, landowners may join these fences by setting posts adjacent to them.

(a) Stock Fences.

The fabric shall be placed by securing or fastening one end and applying sufficient tension to remove approximately one-half of the tension curve in the wire before making permanent attachment elsewhere. The fabric and barbed wire shall be fastened to the posts in accordance with the details shown on the Plans. All bolts and clips or ties used to fasten wire or fittings to the posts shall be drawn up tightly. Bolts shall have sufficient length to extend at least ¼ in.(6 mm) through and beyond the full

nut, except where such extension might constitute a safety hazard, in which case the bolt shall be cut off flush with the nut.

(b) Chain-Link Fence.

The fabric shall be placed by securing one end and applying sufficient tension to remove all slack before making attachment elsewhere. The fabric shall be fastened to the posts at intervals not exceeding 14 in.(350 mm). When specified, the top rail shall be connected with expansion sleeves to form a continuous rail, and the fabric fastened to the rail at intervals not exceeding 2 ft.(600 mm). When aluminum-alloy fabric is used, a tension wire shall be attached to the bottom of the fabric by means of a hog-ring type fastener at a maximum of 2 ft.(600 mm) intervals and secured at the terminal posts by means of brace bands.

Barbed wire shall be pulled taut before being permanently attached to a post or extension arm.

When chain-link or stock fences cross short depressions or ditches, water crossings or water gates shall be constructed of the type, at the locations and in accordance with the details indicated on the Plans or as directed by the Engineer.

Fence gates shall be constructed and installed in accordance with the details shown on the Plans or as directed by the Engineer.

707.07-Final Finishing and Cleanup. After fences have been placed in final position, they shall be inspected, and all excess or unsuitable material shall be disposed of as directed by the Engineer.

Final Cleanup shall be performed in accordance with the provisions of **Subsection 104.11.**

COMPENSATION

707.08-Method of Measurement. Fences will be measured for payment by the linear foot(meter) along the bottom of the fabric and from end to end of the fence, complete in place, deducting the width of openings.

No measurement for payment will be made for projections, anchors etc., beyond the end posts.

Gates will be measured for payment by the unit, per each, complete in place, for the kinds and dimensions as shown on the Plans.

End, braced line, and corner post assemblies conforming with Plans details will be measured in accordance with the following:

- (a) Chain Link Fence: Each assembly consisting of 1 post and 1 or more horizontal rails and 1 or more truss rods, as detailed on the Plans will be measured by the unit.
- (b) Stock Fences: Each assembly consisting of 1 post, diagonal or horizontal braces and tie wires as detailed on the Plans, will be measured by the unit.

Water Crossings, complete in place, will be measured for payment by the linear foot(meter). Measurements for determination of length for payment will be performed in accordance with the details shown on the Plans.

Water Gates, complete in place, will be measured for payment by the square foot(square meter). Measurements for determination of area will be performed in accordance with the details shown on the Plans.

No measurements for payment will be made for excavation and backfilling or for concrete for anchors and post embedment as this is a necessary part of the construction and a responsibility to be assumed by the Contractor.

707.09-Basis of Payment. Accepted quantities of fence will be paid for at the contract unit price per linear foot(meter), complete in place, for the kind shapes, and dimensions of fence stipulated or shown on the Plans.

The accepted quantities of gates will be paid for at the contract unit price per gate, complete in place, for the kind and dimensions of gates stipulated or shown on the Plans.

End, braced line and corner posts assemblies measured in accordance with **Subsection 707.08** will be paid for at the Contract unit price per each assembly.

The accepted quantities of Water Crossings will be paid for at the contract unit price per linear foot(meter), complete in place.

The accepted quantities of Water Gates will be paid for at the contract unit price per square foot(square meter), complete in place.

708

SECTION 708-MONUMENTS AND MARKERS

708.01-Description 579
708.02-Materials..... 579
708.03-Equipment 579
708.04-Foundation Preparation..... 579
708.05-Manufacture and Erection of Monuments and Markers..... 580
708.06-Final Finishing and Cleanup 580
708.07-Method of Measurement..... 581
708.08-Basis of Payment..... 581

SECTION 708-MONUMENTS AND MARKERS

708.01-Description. Monuments and Markers shall consist of furnishing and erection of monuments or markers composed of portland cement concrete, , , or other materials approved by the Engineer. Monuments and Markers shall be of the kind, size, dimensions, shapes, and markings as indicated on the Plans and shall be constructed, set or placed at such locations and in reasonably close conformity with the lines and grades indicated on the Plans or as directed by the Engineer, and in accordance with the requirements of these Specifications.

MATERIALS

708.02-Materials. Concrete used in manufacturing monuments and markers shall be Class A, and shall be composed of materials including reinforcement meeting the requirements of **Subsection 604.02**.

Concrete rights-of-way markers shall have a smooth finish, and be fabricated in accordance with the Plans.

Stone for monuments and markers shall meet the requirements of **Subsection 918.10**.

Metal materials shall conform to the requirements shown on the Plans or stipulated in special provisions.

Paint, if required, shall meet the requirements of **Section 910** for the kind and type of paint called for on the Plans.

EQUIPMENT

708.03-Equipment. All equipment necessary for the satisfactory performance of this work shall be on hand and approved by the Engineer before construction will be permitted to begin.

This equipment shall include the hoisting equipment, rollers, skids, protecting mats, etc., necessary to handle monuments or markers without damage.

CONSTRUCTION REQUIREMENTS

708.04-Foundation Preparation. Excavation for monuments shall, unless otherwise shown on the Plans, be not less than 6 in.(150 mm) larger on all sides than the base of the monument, and shall be carried to a depth not less than 6 in.(150 mm) below the grade of the base of the monument, unless solid rock is encountered. Any soft or yielding material in the foundation shall be removed to such depth as ordered by the Engineer, and refilled and tamped in 6 in.(150 mm) layers with material satisfactory to the Engineer. If solid rock is encountered, it shall be excavated below the grade of the base, cleaned of any soft or flaky material and brought to a true even grade.

The foundation for any monument shall be of such character as will hold the monument in place and in its intended position, and shall be approved by the Engineer.

The excavation for markers shall be prepared by digging holes to the depth as indicated on the Plans, or as directed by the Engineer, and of such

size as will permit satisfactory backfilling and tamping. If rock is encountered above the grade of the base of the marker, the marker may be cut off, provided it is set 1 ft.(300 mm) in solid rock and the area around the marker is filled with Class A concrete, or mortar meeting the requirements of **Subsection 905.02**. The backfill shall be placed in 6 in.(150 mm) layers and each layer shall be thoroughly and satisfactorily tamped, and when the backfilling is completed, the marker shall be substantial and unyielding.

708.05-Manufacture and Erection of Monuments and Markers. Concrete monuments and markers may be precast or cast-in-place. The concrete shall meet the requirements of **Subsection 604.03** for Class A concrete. Manufacture of the monuments and markers shall be in accordance with the applicable provisions of **Section 604**, Concrete Structures.

Stone monuments and markers shall be cut from stone conforming to the requirements of **Subsection 918.10** and shall be of the size and shape, and contain such other details as indicated on the Plans or as directed by the Engineer.

Markers shall be placed in the prepared excavation and held firmly in place, true to line and grade, until backfilled. Backfill shall be placed in 6 in.(150 mm) layers and each layer thoroughly tamped.

Stone or precast monuments shall be installed or erected on the prepared foundation, set accurately at the proper elevation, and in such manner as to insure their being held firmly in place. They shall be set on blocks or shims to line and grade, and the excavation below the bottom of the monument filled with Class A concrete. The concrete shall be worked in, under, and around the base of the monument until all voids are filled. After the concrete has set, the remainder of the excavation shall be backfilled to the natural ground line with suitable material.

Painting, if called for on the Plans, shall be performed in accordance with the requirements of **Section 603**.

708.06-Final Finishing and Cleanup. After monuments or markers have been placed in their final position, they shall be inspected and any defects or scars removed.

The surface of the ground immediately around each installation shall be shaped neatly to the established grade. All excess material shall be disposed of as directed.

Final Cleanup shall be performed as prescribed in **Subsection 104.11**.

COMPENSATION

708.07-Method of Measurement. Monuments and Markers will be measured for payment by the number of individual units furnished, placed and accepted, complete in place.

No measurement for payment will be made for excavation or preparation of the foundation.

No measurement for payment will be made for materials or concrete used in preparing foundations or backfilling excavation.

708.08-Basis of Payment. The accepted quantities of Monuments and Markers will be paid for at the contract unit price per monument or marker, complete in place.

709

SECTION 709-RIPRAP AND SLOPE PAVEMENT

| | |
|--|-----|
| 709.01-Description | 583 |
| 709.02-Materials | 583 |
| 709.03-Classification | 584 |
| 709.04-Equipment | 584 |
| 709.05-Preparation of Foundation | 585 |
| 709.06-Rubble-Stone Riprap(Grouted) | 585 |
| 709.07-Sacked Sand-Cement Riprap | 586 |
| 709.08-Reinforced Concrete Slope Pavement | 586 |
| 709.09-Machined Riprap | 587 |
| 709.10-Final Cleanup | 587 |
| 709.11-Method of Measurement | 587 |
| 709.12-Basis of Payment | 588 |

SECTION 709-RIPRAP AND SLOPE PAVEMENT

709.01-Description. Riprap shall consist of furnishing and setting or placing, rubble stones, crushed stone, or sacked sand-cement. Slope Pavement shall consist of the construction of a reinforced concrete mat on prepared slopes. The riprap and slope pavement shall be constructed within reasonably close conformity to the lines, grades, and cross sections, and at the locations indicated on the Plans or as directed by the Engineer, and in conformity with the requirements and provisions of these Specifications.

MATERIALS

709.02-Materials. Materials used in the construction of riprap and slope pavement, in addition to meeting the general requirements of these Specifications, shall conform to the following:

- (a) Rubble-stone Riprap shall consist of stone or broken Class "A" or paving concrete meeting the requirements of **Subsection 918.10**. In addition, at least 80% of the stone shall have a minimum dimension of 10 in.(250 mm). The remainder shall be 2 to 4 in.(50 to 100 mm), and shall be approximately rectangular and/or trapezoidal in shape. Broken Class "A" or paving concrete shall be free of steel and wire fabric reinforcement. Sand for rubble-stone riprap(grouted) shall meet the requirements of **Subsection 903.01** or **903.02**. Cement for rubble-stone riprap(grouted) shall meet the requirements of **Subsection 901.01**.
- ((b) Sand for sacked sand-cement riprap shall be manufactured or natural sand and shall meet the quality requirements of **Subsection 903.01** or **903.02**. Cement for sacked sand-cement shall meet the requirements of **Subsection 901.01**. Sacks shall be of either cotton or jute, standard grade of cloth, which will hold the sand-cement mixture without leakage during handling and tamping. They shall be strong and shall be sized to hold approximately 1 c.f.(0.03 m³).
- (c) Reinforced concrete slope pavement shall be composed of Class A concrete meeting the requirements of **Subsection 604.03** and steel reinforcement meeting the requirements of **Subsection 907.01** or **907.03**, whichever is specified. Preformed expansion joint filler shall meet the requirements of **Subsection 905.01**.
- (d) Concrete curing materials shall meet the requirements of **Section 913**.
- (e) Machined Riprap shall be clean shot rock essentially free of sand, dust or organic materials and shall be the size designated for the class specified. The stone shall be uniformly distributed throughout the size range. The thickness of the stone layer shall be that designated for the specified class herein unless otherwise noted on the Plans.

When rock or stone is used as riprap, the material when subjected to five alternations of the sodium sulfate soundness test(**AASHTO T 104**),

709

shall not have a weighted percentage of loss of more than 12. The material shall be approved by the Engineer before use.

709.03-Classification. Riprap will be classified according to the following designations:

Rubble-Stone Riprap(Grouted)
Sacked Sand-Cement Riprap
Machined Riprap

Machined Riprap(Class A-1) shall vary in size from 2 in. to 1.25 ft.(50 to 375 mm) with no more than 20% by weight being less than 4 in.(100 mm). The thickness of the stone layer shall be 1.5 ft.(450 mm) with a tolerance of 3 in.(75 mm).

Machined Riprap(Class A-2) shall be identical to Class A-1 except that hand placed rubble stone riprap placed 1 ft.(300 mm) thick in accordance with **Section 709** may be substituted for 1.5 ft.(450 mm) of machined riprap.

Machined Riprap(Class A-3) shall vary in size from 2 to 6 in.(50 to 150 mm) with no more than 20% by weight being less than 4 in.(100 mm). The thickness of the 4 in. (100 mm) stone layer shall be as directed on the plans.

Machined Riprap(Class B) shall vary in size 3 in. to 2.25 ft.(from 75 to 675 mm) with no more than 20% by weight being less than 6 in.(150 mm). The thickness of the layer shall be 2.5 ft.(750 mm) with a tolerance of 4 in. (100 mm).

Machined Riprap(Class C) shall vary in size from 5 in.(125 mm) to 3 ft.(1 m) with no more than 20% by weight being less than 9 in.(225 mm). The thickness of the layer shall be 3.5 ft.(1.1 m) with a tolerance of 6 inc.(150 mm).

EQUIPMENT

709.04-Equipment. All equipment necessary for the satisfactory performance of the work shall be on hand and approved by the Engineer before construction will be permitted to begin.

The equipment shall include wooden or metal tamps of sufficient weight and number to properly compact the slopes on which the riprap or slope pavement is to be placed.

Wooden hand tamps, having a tamping face not greater than 1 s.f.(0.1 m²), and of sufficient weight and number to properly tamp the riprap, shall be furnished when sacked sand-cement is used.

Equipment for mixing concrete, cement grout, or sand-cement shall include a mechanical mixer, or, if the Engineer approves hand-mixing for cement grout, a water-tight mixing platform or mixing-box of adequate size.

Necessary small tools or implements shall also be provided.

CONSTRUCTION REQUIREMENTS

709.05-Preparation of Foundation. Immediately prior to the construction of riprap or slope pavement, the slopes or ground surface shall be trimmed within reasonably close conformity to the lines and grades indicated on the Plans or as directed by the Engineer, and shall be thoroughly compacted by the use of hand or mechanical tamps.

On slopes, the bottom of the riprap shall be placed at least 2 ft.(600 mm) below the natural ground surface, unless otherwise directed.

709.06-Rubble-Stone Riprap(Grouted) Rubble-stone Riprap(grouted) shall be constructed upon the prepared foundation, by hand, and the stones shall be set or placed as close together as is practicable in order to reduce the voids to a minimum.

When rubble-stone riprap is constructed in layers, the layers shall be thoroughly tied together with large stones protruding from 1 layer into the other.

The standard depth of rubble-stone riprap shall be 12 in. (300 mm), unless otherwise indicated or directed, and in no instance shall be less than 10 in.(250 mm) in depth. Rubble-stone Riprap shall have an average depth for each 25 s.f.(8 m²) of surface of not less than the depth indicated on the Plans or as directed by the Engineer, or the standard depth required in these Specifications.

Each stone shall be placed with the larger dimension parallel to the surface upon which it is set except as set forth above to provide keys between layers. The length shall be placed as directed by the Engineer and each main stone shall be placed against the adjoining stones in close contact. The stone shall be placed in such a manner as to equally distribute the large stones as far as it is possible.

After a workable area of the riprap has been set, the stones shall be knapped to a uniform surface and the voids shall be thoroughly chinked and filled with the smaller stones and spalls. This work shall continue with the progress of the construction.

After chinking and filling, the voids between the stones shall be completely filled with grout. Care shall be taken to prevent earth or sand from filling the spaces between the stones before the grout is poured.

The grout used to fill the voids shall be composed of 1 part portland cement and 4 parts of sand, measured by volume, and mixed thoroughly with sufficient water to make a grout of such consistency that will flow into and completely fill the voids.

This grout shall be mixed either in a 1-bag mixer or larger for not less than 1 1/2 minutes, or it may be mixed by hand in a watertight box of sufficient capacity to accommodate a batch of at least 1 bag of cement. Hand mixing shall be continued in a manner and for a period satisfactory to the Engineer.

Immediately before pouring the grout, the stones shall be wetted by sprinkling. The grout shall be carefully poured into the voids' between the stones. This work shall begin at the lower portions of the riprap and progress upward. The entire bottom line of voids shall be filled with grout

before the line of voids next above is poured. The pouring of the grout shall be accomplished by the use of vessels of adequate size and shape. Broadcasting, slopping, or spilling of grout from the vessels on the surface of the riprap will not be permitted. Progress of pouring shall be sufficiently slow to prevent the grout from oozing from the voids and flowing over the surface. During the pouring operations and continuing until the grout has assumed its initial set, fiber brooms shall be used to maintain a uniform distribution. The grouting operations shall continue until such a time as all the voids have been completely filled and the grout has set even with the surface of the riprap.

As soon as any section of the grouted riprap has hardened sufficiently, it shall be cured by sprinkling with water until such time that it has been covered with burlap, cotton or jute mats, earth or liquid membrane-forming compound. The mats or earth shall be maintained by soaking with water for a period of not less than 72 hours. The water used for wetting and curing the grouted riprap shall be free from salt or alkali.

709.07-Sacked Sand-Cement Riprap. Sacked sand-cement Riprap shall be constructed by placing sacks, filled approximately $\frac{3}{4}$ full with a mixture of sand and cement, on the prepared foundation. Sand and cement shall be mixed dry, with a mechanical mixer, in the proportion of 94 lbs(43 kgs) of cement to 5 c.f. (0.15m^3) of dry sand, until the mixture is uniform in color. After the mixing has been completed, the sand-cement mixture shall be poured into sacks of approximately 1 c.f.(0.03m^3) capacity until they are approximately three-fourths filled. The sacks shall then be securely fastened with hog rings, by sewing or other suitable methods that prohibit leakage of the mixture from the bags.

The sacks of sand-cement shall be bedded, by hand, on the prepared grade with all the fastened ends on the grade and with the joints broken. The completed riprap shall have a minimum thickness of 10 in.(250 mm), measured perpendicular to the slope. The surface shall not vary more than 3 in.(75 mm) above or below the desired theoretical plane.

The sacks shall be rammed and packed against each other and tamped on the surface in such a manner as to form close contact and secure a uniform surface. Immediately after placing and tamping the sacks of sand-cement, they shall be thoroughly soaked by sprinkling with water. Water shall not be applied under high pressure.

Sacks of sand-cement ripped or broken in placing shall be removed and replaced before being soaked with water.

709.08-Reinforced Concrete Slope Pavement. Reinforced concrete slope pavement shall be constructed as shown on the Plans and in accordance with the applicable requirements of **Section 604**, except that the concrete shall be of such consistency that it will not flow on the slope and that it can be finished to the thickness shown on the Plans.

The slope pavement shall be scored or sawed for a depth of 1 ft.(25 mm) on 6 ft.(2 meter) centers, both ways, or as directed by the Engineer. A $\frac{1}{2}$ in.(13 mm) preformed expansion joint filler shall be used wherever the slope pavement abuts any portion of the bridge sub-structure.

Forms, which may be of wood or metal, shall be removed after the concrete has set. The concrete shall be cured in accordance with the provisions of **Subsection 501.18**.

709.09-Machined Riprap. The Contractor shall exercise care in the preparation of the riprap subgrade to insure that no reduction in the design waterway occurs. No riprap is to be placed until the final subgrade elevation has been verified by the Engineer. When deemed necessary by the Engineer, the riprap shall be rolled down with metal tracked equipment to provide a more dense stone mass with final contours in reasonable conformance to the plans. Placement of the super-structure shall not proceed until the final elevation of the riprap has been accepted by the Engineer.

Upon completion of the work, visual inspection shall reveal that approximately 50% of the surface area consists of stones no smaller than 1/2 of the maximum size specified.

The material shall be dumped and placed by the use of appropriate power equipment in a manner that will produce a surface uniform in appearance. Hand work may be required to correct irregularities.

709.10-Final Cleanup. Final Cleanup shall be performed in accordance with the requirements of **Subsection 104.11**.

COMPENSATION

709.11-Method of Measurement. (Rubble-Stone Riprap(grouted), Concrete Block Riprap and Reinforced Concrete Slope Pavement will be measured by the c.f.(m³), complete in place. The volume shall be obtained from the thickness shown on the Plans and surface measurements. Unless otherwise specified, reinforcement in slope pavement will not be measured for payment, but the costs thereof shall be included in the price bid for slope pavement. Sacked Sand-Cement Riprap will be measured by the c.f.(m³); the volume being the c.y.(mm³) of dry sand, without cement, actually used. No measurement for payment will be made for excavation or for preparing the foundation for riprap and slope pavement.

Machined Riprap will be measured by the ton(metric ton) or c.f.(m³) for the respective items in accordance with **Section 109**, complete in place. However, where Machined Riprap(Class A-2) is specified and the Contractor selects the hand placed rubble stone riprap option, the actual tonnage measured and accepted shall be increased by 50% for payment purposes.

If a filter blanket is required, it shall be constructed as shown on the plans; and the riprap shall be placed in such a manner as to avoid displacing the filter blanket. The cost of the filter blanket shall be included in the riprap bid item with the riprap quantity increased by the tonnage of the filter blanket.

No measurement for payment will be made for excavation or for preparing the foundation for riprap, and filter blanket where specified.

709

709.12-Basis of Payment . Accepted quantities of riprap and slope pavement will be paid for at the contract unit price per c.f.(m³) or ton(metric ton) for the respective items of work, measured as set out above, complete in place.

SECTION 710-UNDERDRAINS

710.01-Description 590
710.02-Materials..... 590
710.03-Kinds and Sizes of Underdrains 590
710.04-Equipment 590
710.05-Aggregate Underdrains 590
710.06-Aggregate Underdrains (with Pipe) 591
710.07-Filter Cloth & Aggregate Underdrain(with & without Pipe) . 591
710.08-Final Cleanup..... 592
710.09-Method of Measurement 592
710.10-Basis of Payment..... 592

SECTION 710-UNDERDRAINS

710.01-Description. This work shall consist of the construction of underdrains composed of stone, gravel, slag, sand, or any 1 of these materials and perforated pipe, semi-circular drain pipe(with connections) or filter cloth. They shall be constructed in accordance with these specifications, on prepared foundations at the locations shown on the Plans, and in reasonably close conformity to the lines and grades indicated thereon, or as directed by the Engineer. The work shall include all necessary excavation and backfill, together with such work and materials as may be necessary to make connections with other drainage structures, as shown on the Plans.

MATERIALS

710.02-Materials. Materials used in this construction, in addition to meeting the general stipulations of these Specifications, shall meet the requirements of the following Subsections:

| <u>Material</u> | <u>Subsection</u> |
|---|-----------------------------------|
| Pipe(Size shown on the Plans) | 914.03, 914.07, 915.02, 915.03 |
| Aggregate for Underdrains | 903.17 |
| Joint Mortar | 905.02 |
| Filter Cloth | 918.27 |
| Polyvinyl Chloride(PVC) Underdrain Pipe | 914.11 |

710.03-Kinds and Sizes of Underdrains. Underdrains shall be of the kinds specified. Unless otherwise specified, circular pipe for underdrains shall have a diameter of 4 in.(100 mm). Semi-circular pipe for underdrains shall have a diameter of 4 5/8 in.(117 mm). In the case of pipe, the size shall be understood to mean the nominal inside diameter.

EQUIPMENT

710.04-Equipment. All equipment necessary for the satisfactory performance of the work shall be on the project and approved by the Engineer before construction will be permitted to begin.

CONSTRUCTION REQUIREMENTS

710.05-Aggregate Underdrains. The trenches to receive the aggregate shall be excavated at the locations and to the dimensions shown on the Plans or as directed by the Engineer. The trench shall be deep enough to intercept the water-bearing strata, and shall be finished smooth and uniform.

Aggregate meeting the requirements of **Subsection 903.17** shall be placed in the trench in 6 in.(150 mm) layers to the depth shown on the Plans. Each layer shall be well tamped with an approved tamp.

No underdrains may be constructed that will not be paved over the same construction season.

710.06-Aggregate Underdrains(with Pipe). The trench to receive the pipe shall be excavated at the locations shown on the Plans, or as directed by the Engineer. In case the dimensions are not shown, the width of the trench shall be not less than the outside diameter of the pipe plus 12 in.(300 mm). The trench shall be deep enough to intercept the water bearing strata and to allow installation of the pipe and cover material. Unless otherwise shown on the Plans, a 2 in.(50 mm) layer of aggregate shall be spread on the bottom of the trench, compacted and brought to uniform grade.

The pipe shall be embedded firmly in the layer of aggregate. Perforated pipe shall be laid with the flow sector and perforations at the bottom.

If an underdrain is extended through a dry fill or other section where perforated pipe is undesirable, it shall be constructed with the pipe specified and all joints shall be mortar joints, approved manufactured joints, or made with connecting bands.

After the pipe has been laid and approved, the backfilling shall be carefully done so that the pipe will not become displaced. The backfilling around the pipe shall be with the aggregate specified. The aggregate around and over the pipe shall be placed in 6 in.(150 mm) layers and each layer thoroughly tamped with a vibratory compactor.

Lateral and other connections shall be made where indicated on the Plans or as directed by the Engineer.

710.07-Filter Cloth and Aggregate Underdrain(with and without Pipe). Trenches shall be excavated at the location indicated on the plans and to the detailed depth and width. The sides and bottom of the trenches shall be prepared to a relatively smooth condition free of sharp objects, obstructions, depressions and debris which might damage the filter cloth during installation.

The material removed from the trench shall be removed from the area and disposed of outside of the rights-of-way at locations obtained by the Contractor unless the Engineer authorizes its disposition within designated locations.

The filter cloth shall be placed with the long dimension parallel to the center-line of the channel and shall be laid loosely without wrinkles or creases. When more than one width of filter cloth is necessary the joints shall be overlapped a minimum of 12 in.(300 mm). Securing pins with washers shall be inserted through both strips of overlapped material and into the material beneath, until the washer bears against the cloth and secures it firmly to the base material. These securing pins shall be inserted through the overlapped cloth at not greater than 2 ft. (600 mm) intervals along a line through the midpoint of the overlap.

The cloth shall be protected at all times during construction from contamination by surface runoff and any cloth so contaminated shall be removed and replaced with uncontaminated cloth at the Contractor's expense. Any damage to the cloth during its installation for subsurface drainage structures, shall be replaced by the Contractor at his own expense. Stone overlaying the cloth shall not be dropped on the cloth from a height

greater than 3 ft.(1 m). The cloth shall be placed such that the downstream edges overlap the upstream edges.

The filter cloth shall be installed in such a manner that all splice joints are provided with a minimum overlap of 3 ft.(1 m). The overlap of the closure at the top of the trench shall be as indicated on the Plans and secured with mechanical ties. Where outlet pipe passes through the fabric, a separate piece of fabric of sufficient size to be wrapped around the pipe and flared against the side of the filled drain fabric shall be used.

Field splices of filter cloth shall be anchored with securing pins as directed to insure the required overlap is maintained. Care shall be taken during the aggregate filler placement operation as well as the pipe installation(when specified) to prevent damage to the filter cloth. To repair a torn, punctured, or otherwise damaged section, a piece of filter cloth is cut large enough to cover the damaged area and overlap all around the damaged area a minimum of 12 in.(300 mm).

The aggregate shall be placed in 6 in.(150 mm) layers and each layer compacted by the use of vibratory compactor to the satisfaction of the Engineer before making the filter cloth closure at the top of the trench. The exposed end of the outfall pipe shall be protected by an endwall matching the existing slope.

The end of the outfall pipe shall be beveled to fit the slope of the endwall. Should the outlet end of the pipe or the endwall fall within the limits of ditch paving, that portion of the ditch paving within the endwall limits necessary to provide a connection with the new endwall, shall be removed to neat lines and the endwall made to blend with the ditch paving.

710.08-Final Cleanup. All excess or unsuitable material shall be disposed of as directed by the Engineer. Final Cleanup shall be performed as prescribed in **Subsection 104.11**.

COMPENSATION

710.09-Method of Measurement. Aggregate Underdrains will be measured for payment by the linear foot(meter) along the centerline of the underdrains, and from end to end of the underdrains, complete in place.

Filter Cloth Underdrains and Filter Cloth Underdrains(With Pipe) will be measured in linear feet(meters) along the center of each line for each type Underdrain(with or without pipe) actually installed.

Lateral Underdrain will be measured in linear feet(metera) with measurements made along the center of the outfall pipe from the center of the Filter Cloth Underdrain to the centroid of the beveled outfall end.

Lateral Endwalls will be measured by the unit, per each, for the type and size as indicated on the Plans.

Six in.(150 mm) Perforated Pipe with Vertical Drain System will be measured for payment by the linear feet(meters) along the centerline of the underdrains, and from end to end of the underdrains, complete in place.

710.10-Basis of Payment. Accepted quantities of underdrains of the various kinds and sizes measured as specified above will be paid for at the contract unit price per linear foot (meter), for the individual kinds and sizes,

complete in place. Such payment shall be full compensation for all excavation, backfill, connections, specials, and all incidentals necessary to complete the construction.

The accepted footage of Filter Cloth Underdrain will be paid for at the contract unit price bid per linear foot(meter) which shall be full compensation for this item complete in place, including the furnishing and installation of the 4 in.(100 mm) perforated underdrain pipe and pipe elbow when an underdrain outlet is required.

The accepted Lateral Underdrains will be paid for at the contract unit price bid per linear foot(meter) which shall be full compensation for excavation of the trench, outlet pipe and the installation of the materials, the backfill of the trench and compaction, thereof, the disposal of excess materials, returning the shoulder and slope to the previously existing normal condition, and for all tools, equipment, labor, and incidentals necessary to complete this item of work.

The accepted Lateral Endwalls will be paid for at the contract unit price bid per each which price shall be full compensation for excavation, concrete, backfill, compaction, disposal of excess material, and for all tools, equipment, labor, and incidentals necessary to complete this item of work.

The accepted 6 in.(150 Mm) Perforated Pipe with Vertical Drain System will be paid for at the contract unit price bid per linear foot(meter) which shall be full compensation for the pipe and pipe elbows, the installation of the materials including the polyethylene sheeting, and for all tools, equipment, labor, and incidentals necessary to complete this item of work.

711

SECTION 711-CONCRETE MEDIAN BARRIER

711.01-Description 595
711.02-Materials..... 595
711.03-Equipment..... 595
711.04-General 595
711.05-Finishing..... 596
711.06-Curing..... 596
711.07-Method of Measurement..... 596
711.08-Basis of Payment..... 597

SECTION 711-CONCRETE MEDIAN BARRIER

711.01-Description. This work shall consist of the construction of cement concrete median barriers upon a prepared subgrade, in accordance with these Specifications and in reasonably close conformity with the line, grades, and typical cross sections shown on the Plans or established by the Engineer.

MATERIALS

711.02-Materials. Materials used in this construction shall meet the requirements of the following Sections or Subsections of Division III, Materials, of these Specifications:

| <u>Material</u> | <u>Subsection</u> |
|--|-------------------|
| Water | 918.01 |
| Portland Cement | 901.01 |
| Fine Aggregate for Concrete | 903.01 |
| Coarse Aggregate for Class A Concrete: Size No. 467, 57 or 67 | 903.03 |
| Cement Concrete Curing Materials | 913.05 |
| Air-Entraining Admixtures | 918.09 |
| Steel Bar Reinforcement | 907.01 |
| Welded Steel Wire Fabric | 907.03 |
| Joint Filler, Preformed Type | 905.01 |

Type I Portland Cement shall be used unless otherwise specified or permitted.

Concrete for Portland cement concrete median barriers shall be Class A concrete, meeting all the requirements prescribed in **Section 604**, Concrete Structures.

EQUIPMENT

711.03-Equipment. All equipment necessary for the satisfactory performance of this construction shall be on hand and approved before the work will be permitted to begin. Such equipment shall include the applicable equipment specified under **Subsection 604.04**.

CONSTRUCTION REQUIREMENTS

711.04-General. Concrete median barriers shall be constructed as shown on the Plans by fixed-form, slip-form or precast methods.

The Contractor shall perform all necessary excavation and backfilling for the barriers and shall satisfactorily dispose of all excess excavated material. The material adjacent to the median barrier base shall be thoroughly compacted as directed by the Engineer.

Slip-formed concrete shall be placed with an approved slip-form placing machine designed to vibrate, consolidate and finish the concrete in one pass

of the machine in such a manner that a minimum of hand finishing will be necessary to provide a dense, homogeneous unit. The sliding forms shall be rigidly held together to prevent spreading of forms, and after passing there shall be no noticeable slumping of concrete. The concrete shall be held at a uniform consistency.

Where the median is concrete, transverse contraction joints will be required in base and barrier to match the adjacent concrete median. Where the median is asphalt, transverse contraction joints will be required in the base and barrier uniformly spaced at 15 to 20 ft.(4.6 to 6 m) intervals. Joints in the barrier shall be directly over the joints in the base. Transverse contraction joints shall be constructed as shown on the Plans. Where concrete median barrier is installed on concrete pavement the joints in the barrier and pavement shall coincide.

Expansion joints shall be constructed in accordance with Plan details. Expansion joints shall be formed about all bridge piers, drainage inlets, concrete gutters and other features projecting through, into or against the barrier curb and base. Joints shall be chamfered in accordance with **Section 604**.

711.05-Finishing. Concrete median barriers shall present a smooth, uniform appearance in their final position, conforming to the horizontal and vertical lines shown on the Plans or as directed by the Engineer. The top surface and the top 6 in.(150 mm) of the barrier shall be checked with a 12 ft.(3.6 m) straight-edge and shall not vary more than 1/8 in.(3 mm) from the testing edge of the straight-edge when placed parallel to the center-line. Deviations in excess of this requirement shall be corrected.

Corrections shall not be made on extruded median barriers until the barrier surfaces have set sufficiently to withstand further damage that could be caused by making corrections. The exposed surface of the median barrier shall be given a rubbed finish(Class 2) or applied texture finish in accordance with **Subsection 604.21** of these Specifications. However, should the median barrier abut a similar barrier on a bridge, the roadway barrier shall be given the same finish as that required on the bridge median barrier.

711.06-Curing. Curing shall be accomplished in accordance with **Subsection 604.23**.

COMPENSATION

711.07-Method of Measurement. Concrete median barrier, of the type specified, will be measured by the length in linear feet(meters), parallel to the centerline of the barrier and shall include the joints but exclude all other openings in the barrier. Unless otherwise provided, all required excavation, backfill, disposal of excess excavated material, reinforcement, joint materials, drilling and grouting, and other incidentals necessary for the construction of concrete median barriers will not be measured for separate payment.

711

711.08-Basis of Payment. The accepted quantities of concrete median barriers will be paid for at the contract unit price per linear foot(meter).

597

712

SECTION 712-TEMPORARY TRAFFIC CONTROL

712.01-Description 599
712.02-Materials..... 599
712.03-Equipment..... 601
712.04-General 601
712.05-Pavement Marking Removal 602
712.06-Temporary Centerline and Lane Marking 603
712.07-Maintenance..... 603
712.08-Adjustment to Plans 604
712.09-Method of Measurement..... 604
712.10-Basis of Payment..... 605

SECTION 712-TEMPORARY TRAFFIC CONTROL

712.01-Description. This work shall consist of furnishing, erecting, and maintaining all construction warning signs, barricades, flexible drum channelizing units, temporary pavement markings and other traffic control devices installed in accordance with the provisions of the current edition of the "Manual for Uniform Traffic Control Devices for Streets and Highways," Federal Highway Administration, including all addenda, or as specified by the Plans or as directed by the Engineer for the purpose of safely directing traffic through construction zones.

MATERIALS

712.02-Materials. All traffic control and marking devices shall be in accordance with the provisions of the current edition of the "Manual on Uniform Traffic Control Devices for Streets and Highways," Federal Highway Administration, except as herein modified.

| <u>Material</u> | <u>Subsection or specification</u> |
|---------------------------------|--|
| Signs: | |
| Aluminum | 916.02(a) |
| Reflective Sheeting | 916.06 |
| Paint | 916.09 |
| Cold Rolled Carbon Steel-16 ga. | ASTM A 366 |
| Non-metallic | QPL |
| Drums and Barricades: | |
| Reflective Sheeting | 916.06 |

Sign sheeting material for all temporary construction signing shall be Type IV or higher, Fluorescent Orange color meeting the requirements of AASHTO M 268 and **Subsection 916.06** of these specifications. Fluorescent orange sign sheeting material on all interstate projects shall be new and all other construction projects, shall have new or previously used sign sheeting that is in good condition.

Temporary Pavement Marking Material:

Unless otherwise specified, the material for pavement marking line shall be either pressure-sensitive adhesive backed wet reflective pavement marking tape, or reflectorized paint with raised reflective pavement markers placed as shown on the plans.

Where Removable Pavement Markings are specified, they shall be listed on the Department's QPL. Prior to use, the manufacturer shall certify to the Department that the removable tape is identical to that listed on the Department's QPL. Failure of the removable tape to perform satisfactorily in regard to wet reflectivity, installation or removability shall be cause for rejection of the material.

712

Cones:

Cones shall be a minimum of 28 in.(700 mm) high and weighted at the base.

Portable Barrier Rail:

Portable barrier rail shall be in accordance with the Plans or listed on the Department's QPL.

All portable barrier rail shall be in compliance with **NCHRP 350**. Portable barrier rails require certification from the supplier that the proposed rail replicates an **NCHRP 350** approved rail documented in an acceptance letter from FHWA. The acceptance letter stating that the proposed rail is in compliance with NCHRP 350 shall be attached to the certification. All certification documents shall be submitted to the engineer before delivery to the project. Rail meeting **NCHRP 230** that is purchased or manufactured prior to 10-1-02 may continue to be utilized until such time that the rail is deemed non-serviceable by the Engineer. Different shapes, lengths or connections of rail shall not be used in the same continuous run.

Portable impact attenuators

Portable impact attenuators shall be in accordance with the Plans and/or Specifications and in compliance with the requirements of **NCHRP 350** for the appropriate test level and be listed on the Department's QPL.

Sign Supports:

Stationary sign supports shall be steel posts meeting the requirements of **Section 916**. Wood may not be used for stationary or portable sign supports. Portable sign supports shall be pre-approved by the Engineer and comply with the requirements of the **NCHRP 350**. Bolts used in splicing supports shall be 5/16 in.(8 mm) diameter galvanized ASTM A 449(SAE J429 Grade 5) or galvanized ASTM A 325.

Vertical Panels:

The substrate material for vertical panels shall be aluminum, meeting the requirements of **Subsection 916.02**, or a high density copolymer polyethylene. The high density copolymer polyethylene shall be flexible and shatterproof for temperatures to -50° F(-45° C)(ASTM D 746). The reflective sheeting shall be ASTM Type IV or higher, meeting the requirements for Fluorescent Orange material as specified in **Subsection 916.06**. The vertical panel(aluminum or copolymer) shall be attached to a steel "U" post(weight 2.0 lbs./ft (3.0 kgs./m)) meeting the requirements of **Subsection 916.03**.

Flexible Drums, Flashing Arrow Boards and Changeable Message Signs:

Flexible Drums, Flashing Arrow Boards and Changeable Message Signs shall be listed on the Department's QPL.

Traffic control devices defined by the FHWA as Work Zone Category 1, and Category 2 devices weighing less than 100 lbs.(45 kgs) must be in

compliance with **NCHRP 350**. All category 1 and category 2 devices shall be selected from the Department's QPL or a notarized letter shall be submitted stating Category 1 devices and Category 2 devices weighing less than 100 pounds(45 kgs.) meet **NCHRP 350** criteria. Documentation from the FHWA stating that the proposed device complies with **NCHRP 350** shall be attached

All certification documents shall be submitted to the engineer before delivery of these traffic control devices to the project.

EQUIPMENT

712.03-Equipment. All equipment necessary for the satisfactory performance of this work shall be on hand and approved before the work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

712.04-General. At the Pre-construction Conference the Contractor shall designate a responsible person who will be assigned to the project to supervise traffic control.

Signs shall be erected in a workmanlike manner such that all supports are plumb, sign panels generally perpendicular to the travelway and legends horizontal so that they effectively convey the intended message. Advanced warning signs shall not be displayed more than 48 hours before physical construction begins. Signs may be erected up to 1 week before needed, if the sign face is fully covered, in a manner approved by the Engineer. The sheeting of the sign shall be free of any damage that would reduce the reflectivity. The use of overlay plates on signs is prohibited. Signs shall be mounted on stationary or portable supports dependent on the type work being performed. Sign supports shall be driven a minimum of 3.5 ft.(1 m) into soil or 1 ft.(300 mm) into solid rock. Where soil and solid rock are both encountered, the depth of the sign support in the ground shall be:

$$d_1 + 3.33d_2 = 1, \text{ where}$$

$$(d_1 + 3.5d_2 = 42)$$

d_1 = depth in m(in.) of support in soil

d_2 = depth in m(in.) of support in solid rock

Stationary sign supports may be spliced, provided the splice is a minimum of 18 in.(450 mm). In addition, the stubs for the splice shall be driven as required above and shall not extend above 18 in.(450 mm) from ground level. The splice shall be fastened with four bolts, 2 placed at each end of the splice. In general, work being performed at spot locations and of short duration will necessitate the use of portable supports properly weighted for stability.

During periods of non-use, warning signs and other devices shall be removed from the work area, covered or otherwise positioned so they do

not convey their message to the traveling public and do not present a safety hazard to drivers. If covered, the covering material shall be maintained in a neat and workmanlike manner during its use. The method of covering the sign face shall not deface or damage the sheeting of the sign.

Barricades and other devices that require lighting shall be lighted, as designated by plans details or as directed by the Engineer, with the use of flashing or steady burning lights. The Contractor will be responsible for procuring and bearing the expense of a continuous power source.

Flaggers with proper attire and paddle shall be provided when necessary to safely handle traffic through the construction zone. Flaggers will be considered a general requirement of traffic control and no direct payment will be made for such.

The Flashing Arrow Board(s) shall be installed at locations shown on the Plans or as directed by the Engineer and shall comply with all requirements of the "**Manual on Uniform Traffic Control Devices for Highways and Streets**"(MUTCD). The Contractor shall take all necessary precautions to insure that the Flashing Arrow Board(s) perform as described herein. Any Flashing Arrow Board that exhibits any type of malfunction including improper dimming shall be corrected or replaced immediately.

The Flashing Arrow Board shall be capable of displaying the following configurations:

1. Right Arrow - 10 lamps flashing in unison forming an arrow
2. Left Arrow - 10 lamps flashing in unison forming an arrow
3. Double Arrow - 5 lamps in each arrow head and 3 lamps in a common shaft all flashing in unison
4. Four Point Caution - 4 outermost corner lamps flashing in unison

The Flashing Arrow Board(s) shall be used in the single arrow mode for lane closure only and shall be situated and aligned so that the flashing arrow is clearly visible and legible. The single arrow mode display shall have 10 lamps flashing in unison. The sequential arrow configuration, chevron arrow configuration, and horizontal bar configuration will not be allowed. The flash rate shall be not less than 25 flashes per minute nor more than 40 flashes per minute. Minimum lamp "on-time" shall be 50% of the cycle.

The Flashing Arrow Board(s) shall be mounted so as to provide a minimum of 7 ft.(2.1 m) between the bottom of the panel and the roadway.

712.05-Pavement Marking Removal. Conflicting pavement markings must be removed to prevent confusion to vehicle operators. Pavement marking removal shall be accomplished by the Contractor in a manner acceptable to the Engineer. The methods listed below are considered as acceptable:

1. Sand blasting using air or water.
2. High pressure water.
3. Steam or superheated water.

4. Mechanical devices such as grinders, sanders, scrapers, scarifiers, and wire brushes.
5. Solvents and chemicals.
6. Burning.

Removal of an existing pavement marking by painting over with black paint or asphalt will not be an acceptable method.

When the method of removal causes sand or other material to be accumulated on the pavement, the residue shall be removed as the work progresses.

Pavement markings shall be removed by such methods that will cause the least possible damage to the pavement. Any damage to the pavement or surfacing caused by pavement marking removal shall be repaired by the Contractor at his expense by methods and materials acceptable to the Engineer. The end result of the removal shall not cause a condition that appears to be a line that conflicts with the current markings.

712.06-Temporary Centerline and Lane Marking. Unless otherwise specified, temporary pavement marking shall be in accordance with the following:

1. The Contractor shall provide 4 in.(100 mm) wide pavement marking line in accordance with the plans for projects which will have traffic maintained overnight. Temporary pavement line markings on intermediate layers of pavement shall be reflective tape, reflectorized paint and raised pavement markers or a combination of the above as shown on the plans or as required by the Engineer, installed to permanent standards before dark hours. Short, unmarked sections will not be allowed. These markings will be measured and paid for as Painted Pavement Marking(Line) in accordance with **Subsections 716.07** and **716.08**. If the existing pavement has established no-passing zones, they shall be preserved; if no-passing zones have not previously been established, they shall be established by the Contractor prior to beginning the work. Two lane, 2 way highways shall be marked with 10 ft.(3 m) long center lines applied on 40 ft.(12 m) centers and appropriate no-passing barrier lines.
2. Where required on the completed permanent surface, 10 ft.(3 m) lane lines, no-passing barrier line and edge line shall be reflectorized paint applied in accordance with **Section 716**.
3. Pavement markings shall be maintained at no additional cost to the Department until they are covered by subsequent paving course or the project is accepted.
4. It will not be necessary to remove pavement markings except for markings which convey conflicting or incorrect information to the traveling public.

712.07-Maintenance. The Contractor shall assume full responsibility for the continuous and expeditious maintenance of all signs, barricades, temporary impact attenuators and all other traffic control devices.

Maintenance shall include replacement of sign panels, barricades, portable impact attenuators and all other devices which in the opinion of the Engineer are damaged or deteriorated beyond continued use. This shall include the replacement of broken supports, plumbing of leaning signs, cleaning of dirty signs, barricades and other devices, repair of defaced sheeting and legend, and replacement of stolen items, etc. Replacement light bulbs or other illumination devices shall be same as original. All items used for traffic control shall be generally maintained in their original placement condition and such maintenance will be considered a part of the original installation cost. Failure to maintain all traffic control devices in such a manner as to provide continuous safety to the public will be cause for suspension of construction operations until proper traffic control is re-established.

712.08-Adjustment to Plans. The Contractor shall be responsible for maintaining traffic through the project in accordance with the traffic control plan and the "MUTCD". If due to his plan of operation or for other reasons the Contractor wishes to make a change in the traffic control plan, he shall submit a plans revision request in writing with the requested change marked in red on the traffic control plans sheets, to the Engineer for approval. The Engineer may adjust the traffic control plan as he deems necessary to insure the safety of the workmen and traveling public.

COMPENSATION

712.09-Method of Measurement. Signs, including Vertical Panels, erected on suitable supports will be measured by the actual square foot(square meter) installed. No deduction will be made for corner radii.

Drums for channelizing traffic will be measured per each. This number shall be determined by counting the maximum number of drums on a job site and in use at any one time. If a construction project is being stage constructed, the number will be counted for each construction phase and summed up for a grand total for the project.

Barricades will be measured by the linear foot(meter) for the type designated.

Delineators and Temporary Flexible Tubular Delineators will be measured per each.

Warning Lights and Flashing Arrow Boards will be measured per each for the type designated.

Portable Barrier Rail will be measured by the linear foot(meter). Separate measurement will be made for the initial installation of portable barrier rail at each site that the rail is used on the project as indicated on the plans or approved by the Engineer. No separate measurement will be made for removing and resetting portable barrier rail on new alignment at the same site to provide for changes in traffic control required by the different phases of construction. The following conditions apply to measurements of portable barrier rail:

- (1) The sites on 1 directional roadway of a divided highway will be considered independently of the sites on the other directional roadway and
- (2) Each bridge for which portable barrier rail is indicated on the plans or approved by the Engineer will be a separate site.

Measurement of Portable Impact Attenuators will be based on the initial installation of each portable impact attenuator. No additional payment will be made for removal, moving and reinstalling impact attenuators at other locations on the project as directed by the Engineer. Payment will be based on the maximum number of portable impact attenuators in place at one time.

Temporary pavement marking line will be measured as described for Painted Pavement Marking Line in **Subsection 716.07** regardless of whether the lines are painted, taped markings or raised pavement markers or a combination of the above as shown on the plans or as required by the Engineer except that Removable Pavement Marking(Line) which will be measured by the linear foot(meter) of installed line.

Unless otherwise specified, no individual measurement will be made of traffic cones, removal of pavement marking or flaggers, as these items will be included in the lump sum item Traffic Control.

712.10-Basis of Payment. The lump sum payment for Traffic Control will be full compensation for furnishing flaggers, traffic cones and removing conflicting and incorrect pavement markings, as required, until project completion.

Payment for Portable Barrier Rail will be by the linear foot(meter) at the contract bid price which shall be full compensation for all materials, installation, maintenance and all incidentals of the work.

Payment for Portable Impact Attenuators will be made at the contract price per Portable Impact Attenuator, complete in place, with total payment based on the maximum number of portable impact attenuators in place at one time as specified in **Subsection 712.09**.

Payment for Signs and Vertical Panels measured per square foot(square meter) shall be full compensation for sign panels with proper sheeting and legend, erecting on proper supports, furnishing all mounting hardware, covering when not in use, relocating, handling and maintaining until project completion.

Payment for Flexible Drums shall be measured per each, for the highest number that is IN USE on the project at one time. This shall be designated by making a notation such as “On October 29, 2004, there were 242 Flexible Drums in use. Pay quantity is 242 Each.”

This will not apply to phase construction projects. On phase construction projects, each phase would need to be treated as a separate project to arrive at a final pay quantity. The highest number used on Phase I, plus the highest number used on subsequent phases, shall constitute the final pay quantity.

Payment for Barricades measured by the linear foot(meter) complete in place, shall be full compensation for materials, equipment, relocating, handling, maintaining, and all incidentals of the work.

712

Unless otherwise designated, all signs, barricades, and other traffic control devices covered by this section shall become the property of the Contractor at the completion of the project. The salvage value for these items shall be reflected in the contract unit price bid.

Ten ft.(3 m) lane line/center line and solid barrier line will be paid for as Painted Pavement Marking(Line) in accordance with **Subsection 716.08.**

Payment for Removable Pavement Marking Line,(8 in.(200 mm)) Barrier Line, Channelization Striping or Stop Line, shall include installation, maintenance and removal of the marking line when it is no longer required.

SECTION 713-HIGHWAY SIGNING

713.01-Description 608
713.02-Materials..... 608
713.03-Equipment 608
713.04-Construction Methods and Requirements..... 608
713.05-Final Cleanup..... 612
713.06-Method of Measurement..... 612
713.07-Basis of Payment..... 613

SECTION 713-HIGHWAY SIGNING

713.01-Description. Highway signing shall consist of the construction of foundations and supports, fabricating, furnishing, assembling, and erecting traffic signs on the supports, including delineators when specified, for a section of highway, its interchanges, frontage roads and roads or streets affording immediate access to the highway.

Highway signs and devices shall be constructed and erected in accordance with these Specifications and **The Manual on Uniform Traffic Control Devices(MUTCD)**, FHWA latest edition, at the locations and within reasonably close conformity to the lines and grades indicated on the Plans or as otherwise directed by the Engineer.

The Plans will indicate the extent and general arrangement of the signs. The Plans are to be used for the general guidance of the Contractor, and any commission or omission shown or implied shall not be cause for deviating from the intent of the Plans and Specifications. If any departures from the Plans and Specifications are deemed necessary by the Contractor, details of such departures and the reasons therefore shall be submitted to the Engineer for approval. No such departure shall be made without the prior written approval of the Engineer. For any departure from the Plans, the Contractor shall submit for approval by the Engineer eight copies of drawings showing complete design of said departure and any other information necessary to complete the sign assembly.

MATERIALS

713.02-Materials. Materials used in this work, in addition to the general requirements of these Specifications, shall conform to the requirements of the following:

| <u>Material</u> | <u>Section</u> |
|-----------------------------------|----------------|
| Highway Signing Material | 916 |
| Portland Cement Concrete, Class A | 604 |

EQUIPMENT

713.03-Equipment. All equipment required for the satisfactory performance of the work shall be on hand and approved by the Engineer before construction will be permitted to begin.

CONSTRUCTION REQUIREMENTS

713.04-Construction Methods and Requirements. Before beginning any excavation or driving any sign posts, the Contractor shall determine the location of any underground electrical lines, drainage, or utility lines in the vicinity and shall conduct his work in such a manner as to avoid damage to them.

All signs are numbered or otherwise identified and shall be located as indicated on the Plans. Any changes in locations shall be approved by the Engineer prior to erection.

Delineators shall be located as indicated on the Plans and in accordance with the **MUTCD**.

The top of all sign footings shall be placed level with the ground line. The existing footings of signs to be eliminated shall be removed 6 in.(150 mm) below ground line.

The Engineer, or Contractor when required, will stake the location of all sign supports and delineators and mark the location of each sign with the number of the sign. After the sign locations have been staked, but prior to ordering any material for the supports, there shall be a field inspection and approval by the Engineer. The Contractor shall construct the signs at the approved locations and complete the work.

(a) Flexible Delineator Posts.

The flexible delineator posts or anchors shall be driven into the ground with equipment that does not damage the posts, anchors or the reflective sheeting. Pilot holes shall be drilled or formed by other means where necessary to obtain the embedment shown on the plans.

(b) Post Supports for Ground Mounted Signs.

This work shall consist of furnishing and erecting post supports consisting of one or more posts of the type specified on the plans. All posts shall be driven into the ground or bolted to a stub in the concrete foundation. Posts shall be plumb, aligned and oriented as shown on the plans. In driving posts, a method shall be used which will not damage or deface the top of the post.

The excavation for sign posts that are to be bolted to or stubbed in a concrete foundation shall be made as nearly to neat lines as possible and all parts of the sign post foundation shall generally be poured against the soil or rock face, but forming below ground level shall be used in sandy soils or when directed by the Engineer. Forming will be required for all concrete work above the finished ground level and the top 12 in.(300 mm) of all concrete work. Necessary braces shall be provided to keep anchor bolts and stubs in proper position. Concrete for foundations shall be Class A, meeting the requirements of **Subsection 604.03**. Forming and concrete work shall be performed in accordance with the provisions of **Section 604**, Concrete Structures. The Contractor shall remove and dispose of all surplus excavated material.

All cracked, chipped, or scratched galvanized steel members shall be repaired with a "touch-up". An approved zinc powder, wire, stick or spray manufactured especially for this purpose shall be used to repair the damaged areas. The zinc powder, wire or stick shall become completely liquid at a temperature no greater than 475° F(245° C). The area to be regalvanized shall be thoroughly cleaned, including removal of slag on welds, and

repaired in accordance with the recommendations of the manufacturer of the material being used.

(c) Foundations for Sign Supports.

This construction covers the furnishing of the materials, labor and all aspects of the complete construction of the foundations upon which the sign supports will be erected.

(1) Excavation and Backfill.

Excavation and backfill shall be performed in accordance with the provisions of **Section 204**, Structure Excavation, Foundation Preparation and Backfill.

(2) Disposing of Surplus or Unsuitable Material.

Surplus or unsuitable material shall be disposed of as provided for under **Subsection 205.06** of these Specifications.

(3) Forms.

Forms shall be constructed in accordance with the provisions of **Subsection 604.05**, Concrete Structures.

(4) Steel Reinforcement.

Steel reinforcement shall comply with the requirements of **Section 604** of these Specifications.

(5) Electrical Conduit.

Electrical conduit, when specified, shall be installed in the foundations in accordance with the Plans.

(6) Concrete.

Concrete shall be Class A complying with the provisions of **Subsection 604.03**.

(7) Placing Concrete.

Placing concrete shall be performed in accordance with the provisions of **Subsection 604.16**.

(8) Setting Anchor Bolts and Stubs.

Anchor bolts and stubs for sign supports shall be set to proper locations and elevations with templates and carefully checked after construction of the sign foundation and before the concrete has set.

(9) Surface Finish.

Finishing shall be performed in accordance with the provisions of **Subsection 604.21**.

(10) Curing.

Concrete shall be cured in accordance with the provisions of **Subsection 604.23**.

(d) Column Supports for Cantilever Structures.

This work shall consist of the fabrication and erection of supports and horizontal arms constructed of galvanized steel. The supports shall consist of 1 or more vertical poles, 1 or more horizontal arms and all necessary fastenings for assembling the units and anchoring the supports to a foundation.

Supports shall be plumbed by the use of leveling nuts. Cantilever supports shall be erected so that the arms are horizontal.

The space between the foundation and base plate of supports shall be completely filled with a non-shrink grout meeting the requirements of **Subsection 918.21**, Type 1, so that the base plate will have a full and even bearing upon the grout.

All high strength bolt connections shall be assembled as specified under **Subsection 602.17**.

All welding shall conform to the requirements of **Subsection 602.19**.

Supports on which galvanizing has been damaged in transportation, handling, and erection will be rejected or may, with the approval of the Engineer, be repaired in the field as specified under **Subsection 713.04(b)**. The repaired area shall be similar in appearance and in coating thickness to the original coating. Supports that are not coated satisfactorily will be rejected.

(e) Supports for Overhead Sign Structures.

This work covers the fabrication and erection of truss sign supports constructed of aluminum or galvanized steel.

The structures shall be erected with the specified camber and in such a manner as to prevent excessive stresses, injury, or defacement.

Brackets shall be provided for mounting signs (including future signs) of the type to be supported by the structure. They shall be adjustable to permit mounting the sign faces at any angle between a truly vertical position and three degrees from vertical. This angle shall be obtained by rotating the front lower edge of the sign forward on the top edge. All brackets shall be of a length equal to the heights of the signs being supported.

Before erecting aluminum end supports, the bottom of each base plate shall be protected with an approved material that will adequately prevent any harmful reaction between the plate and the concrete.

The end supports shall be plumbed by the use of leveling nuts, and the space between the foundation and base plate shall be completely filled with a non-shrink grout meeting the requirements of **Subsection 918.21** for Type I.

All nuts on aluminum trusses, except those used on the flanges, shall be tightened only until they are snug. This includes the nuts on the anchor bolts. A thread lubricant shall be used with each aluminum nut.

All nuts on galvanized steel trusses, with the exception of high strength bolt connections, shall be tightened only to a snug condition. All high strength bolt connections shall be assembled as specified under **Subsection 602.17**.

Requirements for repair of galvanizing on steel trusses shall be as specified under **Subsection 713.04(b)**.

Field welding will not be permitted.

(f) Signs.

This work covers the furnishing, fabrication, and erection of signs on their supports.

When alternates are permitted, all legends, borders, and accessories for an entire project shall conform to the requirements of one and only one of the alternates. The reflective sheeting shall be mechanically applied to the properly prepared aluminum with the equipment and in a manner prescribed by the sheeting manufacturer.

All completed signs shall be free from defects in materials and workmanship and effectively present the specified message under conditions of both day and night viewing. Reflectorized sign surfaces shall exhibit uniform color and brightness over the entire background surface and shall not appear mottled, streaked, or stained when viewed either in ordinary daylight or the incident beam of an automobile headlamp.

The reflectorized legend optical performance shall be such that incident light from motor vehicle headlamps will be uniformly reflected back to the eyes of the operator at entrance angles up to 30° without gaps or irregularities.

Signs shall be positioned on and fastened to the support as shown on the Plans, or as directed by the Engineer. All signs, once erected, shall be clean and free of any substance which would hide or otherwise obscure any portion of the sign face. Flat sheet signs shall be attached to the posts with tamper resistant fasteners.

After the sheeting is thoroughly attached to the sign face, demountable letters, digits, borders, shields and alphabet accessories shall be attached flush against sign faces, with corrosive resistant fasteners as recommended by the manufacturer. A sufficient number of fasteners shall be used to securely fasten demountable legends and borders to sign panels.

Width and placement of demountable borders shall be as shown on the Plans. Spacing of all legends shall be in accordance with the FHWA Standard Alphabets for Highway Signs. Any improper size or spacing of legends and borders shall be cause for rejection of the entire sign.

713.05-Final Cleanup. Before final inspection, the Contractor shall clean exposed sign and support surfaces, and level and repair the site as directed by the Engineer to insure the effectiveness and neat appearance of the work. In addition to the above, final cleanup shall be performed in accordance with the provisions of **Subsection 104.11**.

COMPENSATION

713.06-Method of Measurement. Class A Concrete and Steel Bar Reinforcement for embedment of sign supports, and for foundations for sign supports and overhead sign structures will be measured for payment in accordance with the provisions of **Subsection 604.31**.

Mile(kilometer) Marker and Steel Posts will be measured for payment by the unit(each), complete in place.

Flexible delineator posts with reflective sheeting, anchors and all material necessary for erection of this item will be measured for payment by the unit per each in place.

Aluminum or Steel Hollow Square Posts for sign supports, Aluminum or Steel I-Beams and WF-Beams for sign supports, Structural Steel Hollow Square Posts(Break-Away) for sign supports, and Structural Steel I-Beams and WF-Beams(Break Away) for sign supports will be measured for payment by the pound(kilogram) based on the nominal weight per foot(meter) listed on the sign schedule, for the various sizes and weights used, complete in place.

Aluminum or Steel Overhead Sign Structures and Steel Cantilever Sign Structures will be measured for payment by the unit(each), complete in place. The footings and all incidentals necessary for the construction of Aluminum or Steel Overhead Sign Structures and Steel Cantilever Sign Structures shall be included in the cost per unit(each).

"U" Section Steel Posts will be measured for payment by the pound(kilogram), based on the nominal weight per foot(meter) listed on the sign schedule, for the various sizes and weights used, complete in place.

Flat Sheet Signs will be measured for payment by the square foot(meter)for each thickness, complete in place.

Extruded Aluminum Panel Signs will be measured for payment by the square foot(meter) complete in place, except that the measurement will be made only for the actual dimensions of the extruded panels. No payment will be allowed for any space between panels.

No measurement for payment will be made for conduit, excavation, or for backfilling performed in connection with this construction.

713.07-Basis of Payment. Class A Concrete and Steel Bar Reinforcement will be paid for in accordance with the provisions of **Subsection 604.31**.

The accepted quantities will be paid per unit of measurement, respectively, for each of the pay items listed below that is shown in the bid schedule. This price shall be full compensation for performing all operations incidental thereto; and for furnishing all materials, equipment, tools, labor, and incidentals necessary to complete the item.

**SECTION 714-ROADWAY AND
STRUCTURE LIGHTING**

714.01-Description 615
714.02-Materials..... 615
714.03-Codes 615
714.04-Equipment 616
714.05-Conduit 616
714.06-Pull Boxes 619
714.07-Underground Cable for Lighting Circuits 619
714.08-Light Standards 621
714.09-Bracket Arms 623
714.10-Luminaires 623
714.11-Lamps 624
714.12-Installation of Overhead Wires 624
714.13-Cable Markers 624
714.14-Control Center 624
714.15-Field Painting 624
714.16-Testing After Installation 625
714.17-Repair of Seeded and Sodded Areas 626
714.18 Disposal of Excess or Unsuitable Material 626
714.19-Final Cleanup..... 626
714.20-Method of Measurement 627
714.21-Basis of Payment..... 628

SECTION 714-ROADWAY AND STRUCTURE LIGHTING

714.01-Description. This work shall consist of furnishing and installing Roadway and Structure Lighting Systems complete or to the extent indicated on the Plans. All work shall be performed in accordance with these Specifications and the details shown on the Plans.

MATERIALS

714.02-Materials. Materials used in this construction shall conform to the requirements of **Section 917** and to the following Sections or Subsections, unless otherwise stipulated:

| <u>Material</u> | <u>Section or Subsection</u> |
|--|----------------------------------|
| Gray Iron Castings | 908.07 |
| Portland Cement Concrete, Class | 604 |
| Steel Bar Reinforcement for Concrete Structures | 907.01 |
| Welded Steel Wire Fabric | 907.03 |
| Crushed Stone Grading D | 903.05 |
| Cement Concrete Curing Materials | 913 |
| Aluminum Paint | 910.04 |
| Conduit | 917.05 or 917.07 |

The Contractor shall submit 6 copies to the project Engineer for his transmittal for approval the following, when applicable:

1. Complete photometric data of luminaires as published by the manufacturer with independent testing laboratory results.
2. Computer printouts showing illumination levels throughout each interchange area where high mast luminaires are to be installed.
3. General details of light standards, breakaway bases and bracket arms.
4. Highmast tower details with a set of design computation for each height including access hole, base, anchorage, head frame, and lowering device. Details are to include specification references for materials and location, type, size and extent of welds.
5. Dimension sheets and performance data on all related equipment.

714.03-Codes. All material furnished and all work performed shall be in strict accordance with the latest revision of the **National Electrical Code**, the **National Electrical Safety Code**, the **Illuminating Engineering Society(IES)** publications, the **American National Standards Institute(ANSI)** standards and the codes, regulations, and rules prevailing in the area in which the work is being performed, insofar as they apply.

714.04-Equipment; All equipment necessary for the satisfactory performance of each phase of the work shall be on the project and approved before construction will be permitted to begin.

CONSTRUCTION REQUIREMENTS

714.05-Conduit. Conduit of the type and size specified shall be installed at the locations shown on the Plans, or as directed. Pull or drag wires of the type and size specified shall be installed in conduit at the locations indicated on the Plans.

A. Underground Conduit.

(1) General.

Underground conduit shall consist of encased or direct burial conduit. The conduit shall be installed in a trench excavated to the dimensions and lines specified.

Before beginning any excavation, the Contractor shall determine the location of any electrical lines, drainage or utility lines in the vicinity and shall conduct his work in such a manner as to avoid damage to any of these facilities. Precautions shall be taken to insure that the conduit will be located to avoid conflict with proposed Guardrail, sign posts, etc.

Conduit runs shall be built in straight lines where possible. Where sweeps are necessary, standard long sweep conduit bends shall be used when feasible, and a minimum radius shall be as required by the National Electric Code. Pull boxes shall be installed at intervals so that the tensile strength of the conductors will not be exceeded.

Obstructions encountered when excavating trenches for underground conduit may require minor changes in locations of conduit runs, pull boxes, etc. All such changes shall be subject to the approval of the Engineer. Where possible, a minimum of 12 in.(300 mm) shall be provided between the finished lines of conduit runs and utility facilities, such as gas lines, water mains, and other underground facilities not associated with the electrical system. Where the conduit run is adjacent to concrete walls, piers, footings, etc., a minimum of 4 in.(100 mm) of undisturbed earth or firmly compacted soil shall be maintained between the conduit and the adjacent concrete or, when the conduit is encased, between the encasement and the adjacent concrete.

Unless specified on the Plans, trenches shall not be excavated in existing pavement or surfaced shoulders to install conduit. If it is necessary to place a conduit under an existing pavement, the conduit shall be installed by jacking or other approved means with galvanized rigid steel conduit or schedule 80 PVC conduit.

Jacking and drilling pits shall be kept at least 10 ft.(3 m) from the edge of the paved shoulder or sidewalk unless otherwise directed by the Engineer. When the Plans specifically allow excavation of a trench through an existing pavement or surfaced shoulder, the Contractor shall restore the pavement and/or surface and base to their original condition. Boring pits shall not be left open for extended periods of time. Removal and satisfactory disposal of existing pavement, surface and base and restoring the base, pavement and surface to their original condition will not be paid for directly, and all costs connected therewith shall be included in the unit price bid for other items.

Unless otherwise specified, all trenches for conduit shall be cut on a slight grade for drainage, and the walls of the trench shall be essentially vertical. The bottom of the trench shall be tamped as necessary to produce a firm foundation for the conduit.

Trenches for rigid metallic conduit, with or without encasement, shall be excavated to a minimum depth of 18 in.(450 mm), plus conduit diameter, measured from the finished subgrade.

The Contractor shall sheet and brace the trenches as required, and shall adequately support all pipe and other structures exposed in trenches, if support is necessary to prevent damage. Furnishing, installing and subsequent removal of sheeting, bracing, and supports will not be paid for directly, and all costs connected therewith shall be included in the unit prices bid for other items.

Metallic conduit shall be reamed after threads are cut. Other conduit shall be reamed as necessary. All ends shall be cut square and shall butt solidly in the joints to form a smooth raceway for cables.

Conduit joints shall be made in such a manner so as to form a water-tight seal. Metallic conduit threads shall be coated with pipe compound and then securely connected. Conduit joints shall be made with the materials and in the manner recommended by the manufacturer of the conduit and approved by the Engineer.

Conduit bushings shall be installed in conduit where necessary and required for protection of the conductors. When the conduit is installed for future use, the ends of metallic conduit runs shall be properly threaded and capped; and the ends of non-metallic conduit runs shall be satisfactorily plugged or capped to prevent water or other foreign matter from entering the conduit system.

(a) Encased Conduit.

Encased conduit shall be placed under roadway and paved shoulders unless trenching is required for installation at the locations shown on the Plans and,

unless otherwise specified, shall be constructed in accordance with the following: The encasement shall be constructed of Class A concrete meeting the requirements of **Section 604**, except that the coarse aggregate shall be size 67 or 78. The encasement of conduit under roadway pavements or surfaces shall extend to the outer edges of the surfaced or paved shoulders, or 1 ft.(300 mm) beyond the outer edge of the sidewalk, or 1 ft.(300 mm) beyond the outer edge of the curb when no shoulder or sidewalk is indicated. The conduit shall extend at least 6 in.(150 mm) beyond the encasement. The pipe shall be encased by a minimum of 3 in.(75 mm) of concrete. The ends of the conduit shall be plugged temporarily to prevent the entrance of concrete or other foreign material. No conduit shall be encased with concrete until inspected and approved by the Engineer. Concrete encasement shall be cured in accordance with **Subsection 604.23**, except that the curing period may be reduced to 24 hours if backfilling is to proceed at that time in accordance with part A(2) of this Subsection.

(b) Direct Burial Conduit.

When rock is encountered in the bottom of the trench, the conduit shall be installed on a bed of well compacted fine grain soil at least 4 in.(100 mm) thick.

(2) Backfilling Conduit.

Encased conduit shall not be backfilled until the concrete encasement has cured a minimum of 24 hours. After the installation of direct burial conduit has been inspected and approved by the Engineer, it shall be promptly backfilled to the required grade with approved material in layers not exceeding 6 in.(150 mm) in loose depth, and each layer shall be compacted as directed by the Engineer.

B. Conduit on Structures.

Conduits, conduit fittings, hangers, expansion fittings, and accessories shall be installed on structures in accordance with the Plans and, unless otherwise specified, in accordance with the following:

Conduit shall run parallel to beams, trusses, supports, pier caps, etc., in the most direct manner. Horizontal runs shall be installed on a slight grade, without forming low spots, in order that they may drain properly. Conduits shall be run with smooth, easy bends. They shall be held in boxes with locknuts and shall have bushings for protection of the conductors.

C. Testing Conduit.

After the installation of conduit is completed, it shall be tested by the Contractor with a metallic mandrel in the presence of the

Engineer. The mandrel shall have a diameter 1/4 in.(6 mm) smaller than the conduit, and a length of 2 in.(50 mm). All conduits which will not allow the mandrel to be pulled through shall be repaired to the satisfaction of the Engineer. If repairs cannot be effected, the conduit shall be removed and replaced at no additional cost to the Department.

After the mandrel test, all conduits shall be scoured with a stiff wire brush slightly larger in diameter than the conduit.

Conduits which have been installed under a previous contract shall be tested with a mandrel and cleaned as described above before the cables are installed.

714.06-Pull Boxes. Pull boxes shall be constructed in accordance with the design, dimensions, and at the locations shown on the Plans. Concrete pull boxes shall be constructed of Class A concrete meeting the requirements of **Section 604**. Non-Metallic pull boxes are to be placed only in nontraffic bearing locations and are not to be placed in paved areas.

A cast iron frame and cover or reinforced concrete cover, as specified on the Plans, shall be provided with each pull box.

Unused conduit entrance holes and openings for conduit to be extended by others shall be blanked off with suitable plugs of plastic, bituminous fiber, or other approved material to prevent the entrance of foreign matter.

714.07-Underground Cable for Lighting Circuits. Underground cable for lighting circuits shall consist of direct burial cable, preassembled cable in duct, and/or cable in conduit, as shown on the Plans.

If it is necessary to install a cable under an existing pavement or surfaced shoulder, conduit, when specified, shall be installed in accordance with the applicable provisions of **Subsection 714.05** and the cable placed therein.

Walls of trenches for cables shall be essentially vertical. Unless otherwise specified, underground cable shall be installed in accordance with the following:

Trenches for direct burial cable shall be excavated to a minimum depth of 24 in.(600 mm) plus cable diameter measured from finished subgrade. In general, the trenches shall be located to avoid conflict with proposed guardrail, sign posts, etc.

Direct burial cable and preassembled cable in duct shall be protected in the trench by a cushion of sand or earth, all of which passes a 1/4 in.(6 mm) screen. The cable or preassembled cable in duct, and sand or earth shall be placed in the trench so that each cable will be completely surrounded with a minimum 3 in.(75 mm) thickness of the cushion material.

(A) Direct Burial Cable.

Cables shall not be unreeled and pulled into the trench from one end. They shall be unreeled and laid alongside the trench and then laid in the trench. The cables shall be allowed to "snake" slightly in the trench to allow slack for settling of earth. There shall be no crossovers of cable in the trench. Where cable is

brought up into the base of the lighting standard, sufficient slack shall be left to enable making the connections inside the standard.

(B) Preassembled Cable in Duct.

When being installed in the trench, preassembled cable in duct shall not be pulled taut, but shall be allowed to "snake" in the ditch to allow not less than 18 in.(450 mm) slack per 100 ft.(30 m) of trench. Minimum bending radius on the cable duct shall be 18 in.(450 mm). Where the duct is brought into the base of the lighting standard or into a pull box, sufficient length shall be left to enable trimming the duct to expose enough cable to permit making the connections inside the standard or pull box.

(C) Cable in Conduit.

Cables in conduits shall be carefully pulled into place using approved methods so that the cable will be installed free from electrical or mechanical injury. All cables within a single conduit shall be pulled at the same time. If necessary to ease the pulling, lubricant of the type recommended by the manufacturer of the cable may be used. When cables are pulled through hand holes in pole shafts, etc., a pad of firm rubber or other suitable material shall be placed between the cable and the edges of the opening to prevent cable damage.

After the cable has been installed in the conduit, the ends of buried conduit shall be sealed with approved pliable and non-hardening material to prevent the entrance of dirt, moisture or other foreign material.

(D) Splices.

Splicing of conductors shall be performed in accordance with the details shown on the Plans. Splicing will be allowed only at accessible points, such as handholes, pull boxes, etc., unless otherwise specified on the Plans. After making a conductor splice, insulate it with heat-shrinkable tubing, supplied by the manufacturer, with an adhesive coating on the inner wall.

(E) Ground Wire.

The ground conductor shall be of the type and size shown on the Plans and shall be continuous in all trenches with direct burial cable, and continuous inside preassembled cable in duct, and in conduit. The ground conductors shall be connected to the ground rod at all control points, to the ground lug in pole foundations and to all metallic conduit runs using a grounding bushing, except that the connections to conduit in pole foundations may be omitted. All connections shall be made in accordance with the details shown on the Plans.

(F) Backfilling Underground Cable.

Backfilling materials and methods shall meet the requirements set out in **Subsection 714.05**.

(G) Cable Identification.

To assist in the identification of circuits at the pull boxes, the phase conductors shall be marked with colored rubber-based, or equivalent, paint. When final connections are made, permanent tape wire markers shall be provided to identify the branch circuit conductors(X1A, X1B, etc.), neutral(X1N, etc.), and the ground(g).

714.08-Light Standards. Light standards of the design, kind, size, and class specified shall be installed in accordance with and at the locations shown on the Plans. The installed standards, complete with the bracket arm(s) and luminaire(s) as specified, shall provide the mounting height shown on the Plans. The Contractor shall be responsible for determining pole height as required by bracket arm upsweep, slope conditions, etc.

A. Foundations for Light Standards. Transformer bases are considered an integral part of the lighting standard unless otherwise specified.

(1) Bolt-Down Base Pole Foundations.

(a) A hole shall be excavated of the size and depth as shown on the Plans. All excavated material shall be removed and disposed of as directed by the Engineer. Anchor bolts of the type and size specified shall be accurately placed in accordance with the recommendations of the pole manufacturer and securely held to insure proper position in the completed foundation. Under no circumstances shall realignment of anchor bolts be allowed after the foundation is poured. Reinforcing steel shall be accurately placed and securely held to avoid displacement.

Conduits in foundations shall be accurately placed, oriented in the proper direction to accommodate service cables, and securely held to avoid displacement.

Class A concrete shall then be placed in the excavated area against undisturbed earth to an elevation 4 in. (100 mm) below the finished ground line, and in an approved form from 4 in.(100 mm) below said ground line to the finished top of foundation elevation, as specified. The foundation shall be constructed with a continuous concrete pour. The top and formed portion of the foundation shall have all edges chamfered. The portion of the foundation above grade and within 4 in.(100 mm) of grade shall be given a Class 2 finish in accordance with the provisions of **Subsection 604.22**.

(b) Metal foundations shall be installed where specified on the Plans and are to be permitted at locations where installation is possible without predrilling the hole.

(2) Prestressed Concrete Butt Base Pole Foundations.

Excavation for prestressed concrete butt base lighting standard foundations may be performed by manual or mechanical methods. The holes shall be dug or drilled to the depth and in the diameter shown on the Plans. Six inches(150 mm) of crushed stone shall be placed in the bottom of the hole and compacted. The crushed stone shall meet the requirements of **Subsection 903.05**, Grading D.

(3) Wood Poles.

Excavation for wood poles shall be performed as prescribed for prestressed concrete butt base pole foundations in part A(2) of this Subsection. The holes shall be dug or drilled to the depth as shown on the Plans and in such diameter to enable mechanical tamping equipment to be used satisfactorily.

B. Light Standard Installation.

The standards or poles shall be handled as recommended by the manufacturer and approved by the Engineer. Erection shall be accomplished carefully to preclude marring the finish or otherwise damaging the standard. The light standards shall be grounded as shown on the Plans. When installing lighting on a bridge, the proposed bridge plans or the completed structure must be examined before ordering the standards.

(1) Bolt-Down Base Poles.

Standards with bolt-down bases shall be set on foundations constructed in accordance with part A(1) of this Subsection. Metal shims supplied with the poles shall be utilized to plumb the pole, if the twin bracket arm type is used; and unless otherwise specified, to rake or lean the pole backward 4 in.(100 mm), if the single bracket arm type is used.

(2) Prestressed Concrete Butt Base Poles.

Prestressed concrete butt base lighting standards shall be placed in the hole and on the layer of crushed stone prepared in accordance with part A(2) of this Subsection. The pole shall be positioned in the center of the hole at grade and held in place. The lighting standards with single bracket arms shall be raked as stipulated for poles with bolt-down bases in part B(1) of this Subsection. The lighting standards with 2 bracket arms shall be set plumb. The space surrounding the pole butt-base shall then be filled with crushed stone, applied 6 in.(150

mm) layers. The crushed stone shall meet the same requirements specified for the stone foundation in part A(2) of this Subsection. The stone backfill material shall be moistened as necessary and each layer shall be thoroughly compacted with mechanical tamping equipment. The backfill with crushed stone shall continue to the depth of the bottom edge of the cable entrance in the butt-base. After the installation of the electrical cable is completed, the crushed stone backfill shall be continued in 6 in.(150 mm) layers and compacted to a depth of 1 ft.(300 mm) below grade. The remaining 12 in.(300 mm) shall be backfilled with soil in 2 equal layers and each layer shall be thoroughly compacted.

(3) Wood Poles.

Wood poles shall be placed in holes excavated in accordance with the requirements of part A(2) of this Subsection. The pole shall be set in the center of the hole with any vertical curvature of the pole located in the plane of the lines, and raked in a direction opposite that of the unbalanced stress where a guy or underbrace is specified. The hole shall then be backfilled with approved material applied in 6 in.(150 mm) layers and each layer shall be thoroughly compacted with mechanical tamping equipment. Cross arms and guying components, when specified, shall be installed in accordance with the details shown on the Plans.

C. Highmast Tower Installation.

Standards with lowering devices shall be installed on foundations constructed in accordance with details shown on the Plans. They shall be plumb. Assembly of the shaft shall be performed in the presence of the Engineer. Field welding will not be allowed between sections of the shaft. The Contractor shall use the manufacturers recommended procedures for erection of towers under supervision of the manufacturer. He shall have adjustments made to align all parts and assure operation. The Contractor shall arrange for the manufacturer or his representative to instruct the local utility in the proper operation of the lowering device.

714.09-Bracket Arms. Bracket arms of the type, design, kind, dimensions, and number specified shall be installed on the lighting standards in accordance with the Plans.

714.10-Luminaires. Luminaires of the design and size shown on the Plans shall be mounted or installed and leveled in accordance with the recommendations of the manufacturer, as detailed on the Plans, and as approved by the Engineer. Glare shields shall be provided on luminaires when shown on the Plans.

The pole and bracket cable shall be clamped in the proper terminals on the terminal board in the luminaire and then spliced to the proper phase and neutral conductors outside of the handhole in the pole base. After other

714

required circuit splices are made outside of the handhole, all of the wire shall be placed inside the handhole. Slack shall be left in all cables for future maintenance. A suitable identification tag shall be attached to each of the phase cables.

Luminaire reflector surfaces and glassware shall be clean after installation. Cleaning, if required, shall be performed in accordance with the luminaire manufacturer's recommendations.

Luminaires for sign lighting shall be adjustable both horizontally and vertically.

714.11-Lamps. Lamps shall be installed of the design, type and size, and at the locations shown on the Plans.

714.12-Installation of Overhead Wires. Overhead wiring, when specified, shall be installed in accordance with the details shown on the Plans.

714.13-Cable Markers. When specified on the Plans, precast or cast-in-place concrete cable markers, of the dimensions indicated, shall be placed at all locations where lighting cables make an abrupt change in direction. The markers shall be constructed of Class A concrete meeting the requirements of **Section 604**. Each marker shall have an arrow imprinted therein that indicates the direction of the cable run as it approaches and leaves the marker. The circuit number shall also be imprinted in the marker.

The markers shall be recessed in the ground approximately 3 in.(75 mm), unless otherwise indicated.

714.14-Control Center. The Contractor shall furnish and install a service pole or poles of the design, type, size, and class, and at the locations shown on the Plans. The service pole(s) shall be installed in accordance with the applicable provisions of **Subsection 714.08** and the details shown on the Plans. The service pole(s) shall be set plumb.

The Contractor shall make prior arrangements to notify the power company at least 30 days before connection, to furnish power to operate the lighting system.

Unless otherwise specified, the Contractor shall furnish and install all the control center equipment and electrical supply facilities. The electrical supply facilities shall include the necessary service conduit from the control cabinet to the delivery point designated on the Plans.

A concrete slab of the dimensions and thickness indicated shall be constructed around the service pole foundation. The slab shall be constructed of Class A concrete meeting the requirements of **Section 604** and shall be reinforced, if specified, as detailed on the Plans.

A 6 ft.(1.8 m) chain-link fence and gate of the size specified shall be constructed around the control center in accordance with the details shown on the Plans and **Section 707**.

714.15-Field Painting. After erection is completed, steel standards not galvanized shall be thoroughly cleaned and then painted with two coats of

aluminum paint meeting the requirements of AASHTO M 69. Painting shall be performed in accordance with the provisions of **Section 603**.

If the shop coat of prime paint is damaged, the damaged areas shall be covered with a coat of the same type of paint as used for the original primer coat and allowed to completely dry before the first coat of aluminum paint is applied.

If the finish on galvanized steel materials is scratched, chipped or otherwise damaged, the material will be rejected, or may, with the approval of the Engineer, be repaired as specified under **Subsection 713.04(c)** of these Specifications.

714.16-Testing After Installation. All materials and equipment shall be installed to form a complete installation ready for operation, unless otherwise specified.

After the installation is completed, the lighting system shall be tested prior to acceptance. Operational tests shall be performed in the presence of a representative of the Department and the Maintaining Agency. Tests shall include insulation resistance, voltage, current and performance tests. Unless otherwise specified, the tests shall be performed in accordance with the following:

A. Voltage Tests.

A voltage reading shall be taken at the control center at the load side of the circuit protection device and last lighting standard served in each branch circuit. In cases where the circuit feeds in two or more directions, the voltage reading shall be taken at the light most remote from the control point or as directed by the Engineer. Unless otherwise specified, with the complete lighting system energized and all lamps operating, the voltage of this last standard shall not be less than 90% of the nominal rated voltage of the luminaire supply circuit, and the voltage at the last underpass luminaire in each branch circuit shall not be less than the minimum operating voltage recommended by the manufacturer of the luminaire ballast.

B. Current Test.

Current tests shall be made at each control center at the load side of each circuit protection device, using a clamp-on type ammeter. Current, in amperes, in each supply conductor shall not be greater than the rated current of a luminaire times the number of luminaires in the circuit.

C. Grounding Resistance Test.

Ground resistance test shall be made with a "megger" manufactured by the James H. Biddle Company, or "vibraground" manufactured by Associated Research Incorporated or approved equal.

The following shall apply during this test (1) No equipment, such as ballast or oil switches, shall be connected at the time of the

test. (2) Only 1 conductor shall be tested at a time. (3) The conductor under test shall be isolated from ground. (4) The other phase conductor and the neutral shall be grounded during each test.

D. Performance Tests.

Prior to acceptance, the Contractor shall operate the lighting system including automatic control equipment and other specified apparatus, for a continuous 48 hour period without interruption or failure attributable to poor workmanship or defective material, after all faults have been corrected. After the 48 hours of continuation of operation, all lights and equipment shall be inspected for normal operation and the Contractor shall make all necessary repairs or replacements to the satisfaction of the Engineer.

The Contractor shall arrange with the Servicing Agency to purchase the electric power necessary to conduct all tests. Cost of labor, materials, equipment, electrical energy and incidentals required for performing the tests will not be paid for directly but shall be included in the unit price bid for other items of construction.

The Contractor shall furnish the Engineer five copies of the test results, together with five copies of a statement from the Maintaining Agency that the system is acceptable to the Agency.

714.17-Repair of Seeded and Sodded Areas. If areas previously seeded or sodded are disturbed during the performance of work described in this Section, the Contractor shall reseed(with mulch) or resod such areas in accordance with the provisions of **Section 801** or **Section 803**, respectively,. These repairs shall precede as the work progresses to minimize the erosion of disturbed areas. The costs incurred in reseeding, resodding, and otherwise restoring the areas to their original condition will not be paid for directly, but shall be included in the unit price bid for other items.

714.18 Disposal of Excess or Unsuitable Material. Excess or unsuitable material shall be disposed of as provided for under **Subsection 205.06**.

714.19-Final Cleanup. Final cleanup shall be performed in accordance with the provisions of **Subsection 104.11**. Existing foundations to be removed shall be removed a minimum of 6 in.(150 mm) below grade. Before final inspection, the Contractor shall perform such touching up of finishes, cleaning of surfaces including signs which are lighted, and such other work as directed by the Engineer to insure the effectiveness and neat appearance of the work.

COMPENSATION

714.20-Method of Measurement. When the bid schedule contains an item for Roadway and Structure Lighting on a lump sum basis, measurement will be for the sum total of all items to be furnished and installed.

When the bid schedule contains items for various elements of Roadway and Structure Lighting, measurement will be made as follows:

- (a) Conduit.
Encased Conduit and Direct Burial Conduit will be measured by the linear foot(meter) of conduit for each kind, number, and size installed as indicated. Conduit(Structures) of the kind and size specified will be measured by the linear foot(meter) of each individual kind and size of conduit placed.
- (b) Pull Boxes.
Pull Boxes will be measured by the unit, per each.
- (c) Cable.
Cable of the type, and number and size of conductors specified, will be measured by the linear foot(meter) from center to center of pull boxes, light standards, etc., for each type, and number and size of conductors. No additional allowance will be made for slack length, length inside equipment or standards, and similar instances where additional length of wire is required.
- (d) Preassembled Cable in Duct.
Preassembled Cable in Duct will be measured by the linear foot(meter) from center to center of pull boxes, light standards, etc. No additional allowance will be made for slack length.
- (e) Light Standards.
Light Standards of the kind and design specified will be measured by the unit, per each.
- (f) Luminaires.
Luminaires of the size, type, and design specified will be measured by the unit, per each.
- (g) Overhead Conductors.
Overhead Conductors of the gauge, type, and kind specified will be measured by the linear foot(meter) between supports. No allowance will be made for slack length.
- (h) Cable Markers.
Cable Markers will be measured by the unit, per each.
- (i) Control Center.
The Control Center will be measured on a lump sum basis, and such measurement will be for the sum total of all items to be

furnished and installed at the control center, except as set out in **Subsection 714.20(j)** and **(k)**.

(j) Class A Concrete.

Class A Concrete used to construct the concrete slab around the service pole at the control center will be measured by the cubic yard(cubic meter). The volume will be obtained from the specified thickness shown on the Plans and surface measurements for width and length. Reinforcement for the concrete slab will not be measured for payment, but the costs thereof shall be included in the unit price for Class A Concrete.

(k) Chain-Link Fence and Gate.

Fence and gates will be measured and paid for in accordance with the provisions of **Subsections 707.08** and **707.09**, respectively.

(l) Navigational Lighting and Overhead Sign Lighting.

Navigational Lighting and Overhead Sign Lighting furnished and installed in accordance with the Plans will be measured on a lump sum basis.

No measurement for payment will be made for excavation, or for backfilling performed in connection with this construction.

714.21-Basis of Payment. When the bid schedule indicates payment will be made for Roadway and Structure Lighting on a lump sum basis, said lump sum payment will be payment in full for all materials, labor, equipment, and incidentals necessary to produce a completely integrated, operative and finished installation of a Roadway and Structure Lighting System, as shown on the Plans.

When the bid schedule contains items for various elements of Roadway and Structure Lighting, payment will be made as follows:

(a) Conduit.

(1) Encased Conduit will be paid for at the contract unit price per linear foot(meter), complete in place, for each kind, number, and size installed as indicated, for which payment shall be full compensation for all excavation, sheeting when required, backfilling, disposal of excess or unsuitable material, furnishing and placing or installing all materials and accessories, including grounding materials, concrete, and reinforcement when specified, all bends, joints, fittings and appurtenances, and installing the encased conduit complete.

(2) Direct Burial Conduit of the kind, number, and size specified will be paid for at the contract unit price per linear foot(meter), complete in place, which price shall be full

compensation for all excavation, sheeting when required, backfilling, jacking of conduit, disposal of excess or unsuitable material, furnishing and placing or installing all materials and accessories, including grounding materials, bedding materials when required, all bends, joints, fittings and appurtenances, and installing the conduit complete.

- (3) Conduit(Structures) of the kind and size specified will be paid for at the contract unit price per linear foot(meter), complete in place, which price shall be full compensation for furnishing and installing all materials, including conduits, hangers, expansion fittings, grounding materials, and associated hardware and accessories, and installing the conduit complete.
- (b) Pull Boxes will be paid for at the unit price per each, complete in place, which price shall be full compensation for furnishing and installing or constructing pull boxes and for all excavation, backfilling, and other work connected therewith.
- (c) Cable of the type, and number and size of conductors, as specified, will be paid for at the contract unit price per linear foot(meter), complete in place, for which price shall be full compensation for furnishing and installing the cable and grounding materials, making splices, joints and connections, and for trenching, furnishing and placing cushion and backfill material, and disposal of excess or unsuitable excavated material.
- (d) Preassembled Cable in Duct of the kind and size specified will be paid for at the contract unit price per linear foot(meter), complete in place, which price shall be full compensation for furnishing and installing the cable duct, grounding materials, making splices and connections, and for trenching furnishing and placing cushion and backfill material and disposal of excess or unsuitable excavated material.
- (e) Light Standards of the type specified will be paid for at the contract unit price per each, complete in place, which price shall be full compensation for furnishing and installing the complete light standards, including the foundation, standard, bracket arm or arms, associated hardware and wiring, grounding materials, excavation, backfilling materials, and backfilling. Foundations for high mast towers are measured separately.
- (f) Luminaires of the size and type specified will be paid for at the contract unit price per each, complete in place, which price shall be full compensation for furnishing and installing the complete luminaire, including the ballast(s), lamp(s), glare shields where required, and associated hardware and wiring.

- (g) Overhead Conductors of the gauge, type and kind specified will be paid for at the contract unit price per linear foot(meter), complete in place.
- (h) Cable Markers of the design specified will be paid for at the contract unit price per each, complete in place, which price shall be full compensation for furnishing and installing the marker complete, including the excavation, backfilling, and removal and disposal of excess or unsuitable excavated materials.
- (i) The Control Center will be paid for at the contract unit price per lump sum, complete in place, which price shall be full compensation for furnishing and installing all equipment and materials, including service pole(s) when specified, and photoelectric relays, relay cabinets, multiple relays, lightning arrestors, fuse cutouts, and all other equipment, materials, associated hardware and accessories, as specified on the Plans. Payment for the Control Center shall also be payment in full for furnishing and installing all electrical supply facilities from the delivery point for electrical energy, as indicated on the Plans, to the control center.
- (j) Class A Concrete measured as specified above will be paid for at the contract unit price per cubic yard (cubic meter), complete in place.
- (k) Navigational Lighting and Overhead Structure Lighting shall be paid by the Lump Sum complete in place including all materials and labor.

**SECTION 715-ASPHALTIC CONCRETE CURB
(HOT MIX)**

715.01-Description 632
715.02-Materials..... 632
715.03-Composition of Mixture 632
715.04-Equipment 632
715.05-Limitations 633
715.06-Preparation of Curb Foundation 633
715.07-Preparation of Mixture 633
715.08-Hauling and Placing Mixture 633
715.09-Curing and Protection..... 633
715.10-Method of Measurement 634
715.11-Basis of Payment..... 634

SECTION 715-ASPHALTIC CONCRETE CURB (HOT MIX)

715.01-Description. This work shall consist of an asphaltic concrete curb composed of a mixture of coarse aggregate; fine aggregate; mineral filler, if specified or required; and asphalt cement, constructed on a prepared foundation in accordance with these Specifications and in reasonably close conformity with the lines, grade and typical cross section shown on the Plans or established by the Engineer.

MATERIALS

715.02-Materials. The materials used in this construction shall meet the requirements of **Subsection 411.02**, except that commercially available stabilizing material may be added when approved.

715.03-Composition of Mixture. The composition of the mixture shall conform to the requirements of **Subsection 411.03** with the following additions and revisions:

- (a) The mineral aggregate and asphalt cement shall be combined in the following proportions:

| <u>Combined Mineral Aggregate</u> | <u>Asphalt Cement</u> |
|-----------------------------------|-----------------------|
| 90-94% | 6-10% |

- (b) The mineral aggregate shall be Grading E except that other gradings may be used, when approved, which have a history of satisfactory performance.
- (c) The job mix formula shall be as necessary to provide sufficient workability during placing and to insure a finished curb of adequate stability and the desired surface texture.

EQUIPMENT

715.04-Equipment. The mixing and hauling equipment for this construction shall meet the requirements of **Subsections 407.04** and **407.05**.

The machine used for placing the curb shall be an approved self-propelled automatic curb machine capable of producing a smooth, well compacted finished curb. The machine shall be equipped with a hopper sufficient in capacity to assure a continuous operation, and a power driven screw or other device which forces the mixture through a tube and then through a die or mold attached to the tube. The mold shall be so constructed as to produce the desired cross section of the curb. The machine shall be so constructed that the thrust against the asphaltic mixture will eliminate objectionable surface voids as the mixture passes through the mold.

CONSTRUCTION REQUIREMENTS

715.05-Limitations. The limitations for this construction shall be as prescribed in **Subsection 407.09**.

715.06-Preparation of Curb Foundation. When the curb is to be placed on a granular base, all soft or otherwise unsuitable material shall be removed and replaced with suitable material. The finished base shall be thoroughly compacted and shaped to the required line, grade and cross section, and primed in accordance with the applicable provisions of **Section 402**.

When the curb is to be placed on an existing pavement, the area receiving the curb shall be thoroughly cleaned of all dirt and other objectionable matter. A Tack coat shall be applied to this area in accordance with the applicable provisions of **Section 403**.

715.07-Preparation of Mixture. The preparation of the asphaltic concrete curb mixture shall be in accordance with the provisions of **Subsections 407.11, 407.12 and 407.13**.

715.08-Hauling and Placing Mixture. The hauling equipment shall be of an approved type and shall be so scheduled that the temperature of mixture when deposited shall be not more than 25° F(14° C), lower than when it left the mixing plant.

The curb shall be placed in position on the tacked or primed surface by means of the approved automatic curb machine which shapes and compacts the mixture to the designated cross section. No side forms will be required for machine placed curb, but where the curb is laid on an existing pavement that does not have a smooth grade, the Engineer may require 2 x 2 in.(50 x 50 mm) angle iron or other approved apparatus to be used as a track so that the finished curb will have a smooth and true line and grade.

Where the curb is to abut an existing structure-wall or is placed at the extreme edge of pavement, a machine shall be used that is capable of placing the curb within 1 in.(25 mm) of the structure-wall or pavement edge. Hand methods of placement will be permitted only adjacent to structures which prohibit machine placing.

On grades greater than 3% the curb shall be placed with the machine traveling uphill. When, in the opinion of the Engineer, the curb is not being adequately compacted corrective action shall be taken. Corrective measures may include adjustment of the mix, loading the machine with additional weight, retarding forward movement of the machine by braking, or other measures which will assure adequate compaction.

Any required joints shall be carefully made in such a manner as to insure a continuous bond between the old and the new sections of the curb.

715.09-Curing and Protection. The newly laid curb shall be protected from traffic by barricades or other suitable methods until the asphaltic mixture has cooled to air temperature.

Any curb or sections of curb which are displaced, destroyed or otherwise damaged before final acceptance shall be removed and replaced.

715

715.10-Method of Measurement. Asphalt Concrete Curb(Hot Mix) will be measured for payment by the linear foot(meter), complete in place.

715.11-Basis of Payment. Asphaltic Concrete Curb(Hot Mix) will be paid for at the contract unit price per linear foot(meter) for the respective items.

SECTION 716-PAVEMENT MARKINGS

716.01-Description 636
716.02-Materials..... 636
716.03-Thermoplastic Pavement Marking 636
716.04-Raised Reflective Pavement Markers 638
716.05-Snowplowable Reflective Pavement Marker..... 639
716.06-Preformed Plastic Pavement Markings..... 640
716.07-Paint..... 640
716.08-Method of Measurement..... 642
716.09-Basis of Payment..... 643

SECTION 716-PAVEMENT MARKINGS

716.01-Description. This work shall consist of furnishing and supplying pavement markings in accordance with these specifications, the latest revision of the "**Manual on Uniform Traffic Control Devices for Streets and Highways**" published by the FHWA, and in reasonably close conformity to the lines, dimensions, patterns, locations, and details shown on the plans or established by the Engineer.

MATERIALS

716.02-Materials. Materials used in this construction shall meet the requirements of the following Subsections of these Specifications:

| <u>Materials</u> | <u>Section or Subsection</u> |
|--|------------------------------|
| Paint | 910 |
| Preformed Plastic Pavement Marking | 918.08 |
| Raised Reflective Pavement Markers | 918.26 |
| Snowplowable Reflective Pavement Markers | 918.20 |
| Adhesive | 918.26 |
| Thermoplastic Pavement Markings | 918.23 |

Plastic pavement markings may be either preformed or thermoplastic unless otherwise specified.

CONSTRUCTION REQUIREMENTS

716.03-Thermoplastic Pavement Marking.

(a) General.

The material shall be applied to the pavement by the screed extrusion method wherein one side of the shaping die is the pavement and the other 3 sides are contained by, or are part of, suitable equipment for heating and controlling the flow of material.

Each application machine must be equipped with an automatic counting mechanism capable of recording the number of linear feet(meters) of material applied to the roadway surface with an accuracy of 0.50%, to be checked by the Engineer.

The equipment shall be constructed to provide continuous mixing and agitation of the material. Conveying parts of the equipment between the main material reservoir and the shaping die shall be so constructed as to prevent accumulation and clogging. All parts of the equipment which come in contact with the material shall be so constructed as to be easily accessible for cleaning and maintenance. The equipment shall be constructed so that all mixing and conveying parts up to and including the shaping die,

maintain the material at the plastic temperature with heat transfer oil or electrical element controlled heat. Direct fire heat transfer will not be allowed.

The equipment shall be so constructed as to insure continuous uniformity in the dimensions of the stripe. The applicator shall provide a method of applying "skip" lines. The use of pans, aprons, or similar appliances which the die overruns will not be permitted under this Specification. The equipment shall be calibrated, and checked periodically by marking over a metal plate. The equipment will be so constructed as to provide for varying widths to produce varying widths of traffic markings.

Glass spheres applied to the surface of the completed stripe shall be applied by an automatic bead dispenser attached to the striping machine in such a manner that the beads are dispensed almost instantaneously upon the installed line. The glass sphere dispenser cut-off shall be synchronized with automatic cut-off of the thermoplastic material.

Special kettle(s) shall be provided for melting and heating the thermoplastic material. The kettle(s) must be equipped with automatic thermostatic control devices so that heating can be done by controlled heat transfer rather than by direct flame, so as to provide positive temperature control and prevent over-heating of the material.

Applicators shall be mobile and maneuverable to the extent the straight line can be followed and normal curves can be made in a true arc.

The applicator equipment to be used on roadway installations shall consist of either hand equipment or truck mounted units depending on the type of marking required.

The hand equipment shall have sufficient capacity to hold 150 lbs(70 kgs) of molten material and shall be sufficiently maneuverable to install crosswalks, lane, edge, and center lines, arrows and legends. The truck mounted unit for lane, edge and center lines shall consist of a mobile self contained unit carrying its own material capable of operating at a minimum speed of 5 mph(8 kph) continuously during an 8 hour period while installing striping.

As an alternate, the Contractor may apply preformed thermoplastic marking material for stop bars, cross walks, legends or directional arrows. The preformed thermoplastic material shall have a minimum thickness of 0.125 in. (3 mm) and fused to the pavement by the heat of a torch.

(b) Application.

The pavement temperature shall be a minimum of 50° F(10° C) and rising before application begins. Application shall be suspended at any time the pavement temperature falls below 50° F(10° C). All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the striping.

To insure optimum adhesion of thermoplastic applied on all portland cement concrete pavement, the Contractor shall apply a binder-sealer material as recommended by the thermoplastic manufacturer. A binder-sealer material shall also be applied to asphaltic concrete pavements which have been open to traffic for ninety or more days. The binder-sealer material will form, when applied with conventional mobile paint spraying equipment, a continuous film over the pavement surface which will dry rapidly and adhere to the pavement surface. The binder-sealer shall be that product currently in use and recommended by the thermoplastic material manufacturer. To insure optimum adhesion, the thermoplastic material shall be installed in a melted state at a temperature of 400 to 450° F(205 to 230° C). The material, when formed into traffic stripes, must be readily renewable by placing an overlay of new material directly over an old line of compatible material. Such new material shall bond itself to the old line in such a manner that no splitting or separation takes place.

Longitudinal lines shall be off-set at least 2 in. (50 mm) from longitudinal joints of Portland Cement Concrete pavements.

Unless specified on the plans, a minimum average film thickness of 0.090 in. (2.25 mm) for lane and edge lines shall be maintained on all markings. This is to be computed on the basis of the amount of material used each day. The film thickness shall be uniform in appearance throughout its application. The glass sphere top coating must be applied by means of a pressure type spray gun designed specifically for this purpose, and which will embed the spheres into the line surface to at least one-half their diameter. The glass spheres shall be applied at the rate of 1 lb of spheres per 10 s.f. (1 kg to each 2 m²) of compound.

When thermoplastic is used on the final surface, the Contractor shall have the option of using reflectorized paint installed to permanent standards at the end of each day's work and then installing the permanent marking after the paving operation is completed. Short, unmarked sections will not be allowed. The temporary markings for the final surface will not be measured and paid for directly, but the costs are to be included in the price bid for the permanent markings.

716.04-Raised Reflective Pavement Markers. Markers shall be bonded to the pavement with a bituminous adhesive conforming to the requirements as described below and spaced as shown on the Plans. Markers shall not be installed over joints in rigid type pavements.

The pavement markers shall be of a type listed on the Department's QPL. The markers shall be installed when the pavement is dry and the pavement temperature is no less than 50° F(10° C).

The portion of the highway surface to which the marker is to be bonded by the adhesive shall be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint and any other material which would adversely affect the bond of the adhesive. Cleaning shall be done by blast cleaning on Portland cement concrete and old bituminous pavements.

New bituminous pavement shall be blast cleaned where, in the judgment of the Engineer, the surface contains an abnormal amount of asphalt or the surface is contaminated with dirt, grease, paint, oil or any other material which would adversely affect the bond of the adhesive.

The bituminous adhesive shall be melted and heated in either thermostatically controlled double boiler type units utilizing heat transfer oil or thermostatically controlled electric heating pots. Direct flame melting units shall not be used. The melter/applicator unit shall be suited for both melting and pumping application through heated applicator hoses.

The adhesive shall be heated to between 375 and 425° F(190 and 220° C) and applied directly to the pavement surface from the melter/applicator by either pumping or pouring. It is important that the application temperature be maintained between 375 and 425° F(190 and 220° C) as lower temperatures may result in decreased adhesion while higher temperatures may damage the adhesive.

The adhesive shall be applied in a puddle approximately 2/3 to 3/4 the diameter of the marker. Markers shall be applied to the adhesive immediately(within 10 seconds) to assure bonding. The marker shall be placed in position by applying downward pressure until the marker is firmly seated with the required adhesive thickness and squeeze out. Excessive adhesive squeeze out shall be removed from the pavement, and adhesive on the exposed surfaces of the markers shall be immediately removed. Soft rags moistened with mineral spirits conforming to Federal Specification TT-T-291 or kerosene may be used if necessary, to remove adhesive from exposed faces of pavement markers. No other solvent shall be used.

Reflective markers shall be installed so that the reflective face of the marker is perpendicular to a line parallel to the roadway centerline. The markers shall be protected against impact until the adhesive has hardened to the degree designated by the Engineer.

The adhesive may be reheated and reused. However, the manufacturer's recommendations regarding the pot life at application temperatures shall not be exceeded.

Clean out of equipment and tanks may be performed using petroleum solvents such as diesel fuel or similar materials. All heating equipment shall be turned off before cleaning operations are begun. All solvent must be removed from the equipment tanks and lines before the next use of the melter.

716.05-Snowplowable Reflective Pavement Marker. The pavement at each snowplowable marker location shall be contoured to match the bottom of the marker casting. Installation procedures shall conform to the recommendations of the marker manufacturer. When utilizing the dry saw method, a vacuum system shall be provided to contain the dust. Regardless of the saw method, the saw cut shall be clean, dry, and free of any dust or residue prior to application of the adhesive. Each shipment of adhesive shall be accompanied by a written statement from the manufacturer of the adhesive certifying that the material furnished conforms to the recommendations of the marker manufacturer, and stating the minimum temperature at which the adhesive can be satisfactorily mixed and/or applied.

716.06-Preformed Plastic Pavement Markings. The application of preformed plastic pavement markings shall be made on clean dry surfaces free of dirt and foreign matter. The pavement temperature shall be 60° F(15° C) or over.

Should plastic require activators for the adhesive or various special coatings for different pavement surfaces, the bidder shall include the cost of the activator or special coatings in the unit price of plastic bid upon.

The vendor will furnish with each package of reflectorized pavement marking materials complete instructions and/or specifications for the application of pavement marking materials to pavement surface.

The reflectorized pavement marking materials are to be installed according to the vendor's specifications.

716.07-Paint. Paint shall be applied by means of a machine of the spray type capable of satisfactorily applying the paint under pressure through a nozzle spraying directly upon the pavement and at a rate not to exceed 880 ft. (270 m) per minute. The machine shall be equipped with an air blast device for cleaning the pavement ahead of the painting operation, a guide pointer to keep the machine on an accurate line, and a device to agitate the paint. It shall also have a device to maintain a uniform flow and application of the paint, an automatic device to provide a broken or skip line of the length required, and at least 2 spray guns capable of being operated either individually or together. When using waterborne paint, the equipment shall be capable of heating the material from ambient air temperature to 123° F(50° C). The machine shall be equipped with a bead or sphere dispenser which can be regulated to dispense the spheres automatically at the uniform rate required. The equipment shall be so designed and operated as to permit traffic to pass on the roadbed with safety.

Paint shall not be applied unless the ambient air temperature is 45° F(7° C) or above. However, if the Engineer deems that paint shall be applied below 45° F(7° C), the paint shall be heated as per manufacturer's recommendations.

Each spray application machine must be equipped with an automatic counting mechanism capable of recording the number of linear feet(meters) of material applied to the roadway surface with an accuracy of 0.50%, to be checked by the Engineer. Each spray application machine shall also be equipped with accurate meters which register paint quantities for both white and yellow applied to the nearest gallon(liter).

Large automatic spray application machinery meeting all of the preceding requirements sometimes is not appropriate and thus will not be required for the following operations, provided the Contractor selects pavement marking equipment capable of producing a uniform, acceptable finished product consistent with the plans and specifications:

1. Installation of temporary pavement markings.
2. Installation of permanent pavement markings on projects having a total length of 1,000 ft.(300 m) or less.

3. Installation of permanent pavement markings on an individual project segment having a total length of 1,000 ft.(300 m) or less on an intermittent project.

Cleaning the pavement surface prior to the placement of any pavement marking material shall be required.

Temporary markings on final pavement surfaces shall be carefully located and placed so as to underlie or coincide with the permanent pavement markings.

Cleaning and painting shall be performed utilizing equipment of the kind and in the manner provided by previously specified equipment. On sections where no previously applied line is available to serve as a guide or if the line is to be re-located, the proposed location of the new line shall be spotted with paint in advance of the application. On tangent sections the control points shall be spaced no more than 500 ft.(150 m) apart and on curves at intervals that will insure the accurate location of the line. Gaps in all lines shall be left at intersections as shown in the **MUTCD**, or as directed.

No paint shall be applied over a chalk line, wire, or cord, but such guide marks shall offset the paint line to be placed. On sections where previously applied lines are visible, the Contractor shall use the old lines unless otherwise directed. No paints shall be applied to areas of pavement when any moisture remains on the surface, or wind conditions are such as to cause a film of dust to be deposited on the line areas after these areas have been prepared for painting.

Drop-on type glass beads shall be uniformly applied to the painted surface at a uniform rate of not less than 6 lbs per gallon(0.7 kgs per liter) of paint applied.

Paint shall be applied so as to deposit a uniform wet film thickness of 0.015 in.(0.38 mm)(within a reasonable tolerance) and shall be applied at a speed not to exceed 880 ft. per minute(10 mph). This is at the rate of 17 gallons per mile(40 liters per km), for a solid stripe 4 in.(100 mm) wide. This rate of application shall apply to all types of paint, with proper adjustment made in gallons(liters) for an intermittent line or wider lines. The quantity of paint shall not under-run the designated amount by more than 5%, and if a check of the rate of application indicates a greater variation than this, the work shall be stopped until the paint machine is properly adjusted or replaced. This per cent of variation is set out to give the Contractor some leeway in starting the job and in getting his machine in adjustment, but it is not expected that there shall be either a continuous overrun or under-run but that the final figures shall indicate that the average rate of application closely approaches the rate established above.

When reflectorized paint is required for temporary or final marking, the paint shall be installed to permanent standards at the end of each day's work. Short, unmarked sections will not be allowed.

Protection of traffic lines and markings shall be provided by the Contractor. Warning and directional signs as shown on the Plans or as directed shall be placed to control traffic in the marking area. If the drying time of the material being used exceeds 60 seconds, the newly applied markings shall be protected by placing traffic cones or other approved

warning devices at frequent intervals as directed. These devices shall be left on the line until the material is dry or firm enough not to track or receive impressions from normal traffic. They shall be removed as soon as possible (because of the traffic hazard) and shall never be left in the roadway overnight. If so directed, flaggers shall be provided to direct traffic.

The general appearance shall be that of clearly delineated lines with a minimum crooked and waving appearance, due consideration being given to the contours and roughness of the pavement. Segments of broken line stripe shall square off positively at each end. The paint lines shall be without mist, drip or splatter. Lines that do not meet these requirements when placed shall be removed and/or corrected by the Contractor to the satisfaction of the Engineer and without extra compensation.

The paint equipment shall be so operated that it will be unnecessary for traffic to cross the newly painted line behind the equipment in order to safely pass the painting machine, and traffic shall be allowed to keep moving at all times.

Removal of Painted Markings. Painted pavement markings shall be removed where specified or directed by the Engineer. The method used for paint removal shall be approved by the Engineer prior to the beginning of the work. Removal of existing painted pavement markings by painting over with black paint or asphalt will not be allowed.

When the method of removal causes sand or other material to be accumulated on the pavement, the residue shall be removed as the work progresses. Painted markings shall be removed by methods that cause the least possible damage to the pavement. All damage to the pavement or surface caused by pavement marking removal shall be repaired as directed by the Engineer at the Contractor's expense.

Where a plastic marking will replace the painted marking and paint removal is specified in the contract documents, enough of the paint shall be removed to assure proper installation of the plastic. The paint removal shall be uniform and shall expose a minimum of 75% of the surface area that is to receive the plastic materials.

COMPENSATION

716.08-Method of Measurement.

- (a) Pavement Marking(Broken lane lines), Pavement Marking(Dotted line) and Pavement Marking(Transverse Shoulder) - The length of each of the above markings complete in place and accepted will be measured as listed in the bid schedule along the center of each line. Only the marked line will be measured for payment.
- (b) Pavement Marking(Solid barrier line) - The length of solid barrier line complete in place and accepted shall be measured along the center of each line. Where double solid barrier lines are used, each solid barrier line will be measured separately for payment.

- (c) Pavement Marking(Crosswalk Striping) and Pavement Marking(Stop line) - The length of the above markings complete in place and accepted will be measured in linear feet(meters) along the center line of the crosswalk or stop line as applicable. Any boundary lines on crosswalk will not be measured separately.
- (d) Pavement Marking(Channelization Striping)-Channelization striping including the boundary lines complete in place and accepted shall be measured and computed by the square yard(square meter).
- (e) Pavement Marking(Stop lines) - The length of stop lines complete in place and accepted will be measured in linear feet(meters) to the nearest foot(meter) along the centerline of the stop line.
- (f) Pavement Marking(Designs) Designs or lettering will be measured for payment by the unit(each) complete in place or as stipulated in the contract and on the plans.
- (g) Raised Reflective Pavement Markers and Snowplowable Reflective Pavement Markers - The number of each type of pavement markers installed as directed and accepted will be counted separately for payment.
- (h) Removal of Existing Painted Line - The removal of broken lane line and solid barrier line will be measured along the center of each line. Only the painted line will be measured for payment.

No measurement for payment will be made for adhesives as these will be included in the cost for the installation of raised reflective pavement markers and snowplowable reflective pavement markers.

716.09-Basis of Payment. The Contractor shall be required to establish and locate non-passing zones as well as providing the layout of paint striping, preformed plastic pavement markings, raised reflective pavement markers, snowplowable reflective pavement markers and thermoplastic pavement markings. The contract unit bid price, complete in place, shall be full compensation for layout, materials, labor, equipment, tools, royalties, and other necessary incidentals required to complete the work.

717

**SECTION 717-MOBILIZATION OF FORCES,
SUPPLIES AND EQUIPMENT**

| | |
|---|------------|
| 717.01-Description | 645 |
| 717.02-Method of Measurement | 645 |
| 717.03-Basis of Payment..... | 645 |

SECTION 717-MOBILIZATION OF FORCES, SUPPLIES AND EQUIPMENT

717.01-Description. This work shall consist of the mobilization and demobilization of the prime Contractor's and all Subcontractors' forces, supplies, equipment and incidentals at the project site. It shall include all Contractor and Subcontractor costs associated with obtaining performance bonds, insurance required by railroads, and other preconstruction costs incurred after award of the contract which are necessary costs to the project and are of a general nature rather than directly attributable to other pay items. All necessary preconstruction costs not attributable to a specific pay item shall be included in the contract lump sum price for Mobilization and not in any other pay item.

717.02-Method of Measurement. Mobilization will be measured by the unit for the completion of the work as described above, and payment will be made on a lump sum basis.

717.03-Basis of Payment. Partial payments for the item of "Mobilization" will be made with the first and second partial pay estimates paid on the contract, and will be made at the rate of 50% lump sum price for "Mobilization" on each of these partial pay estimates provided the amount bid for "Mobilization" does not exceed 5% of the total amount bid for the contract. Where the amount bid for the item of "Mobilization" exceeds 5% of the total amount bid for the contract, 2 ½% of the total amount bid will be paid on each of the first partial payment estimates, and that portion exceeding 5% will be paid on the last partial pay estimate.

As an exception to the above, where the work covered by the contract is limited exclusively to the resurfacing of an existing pavement, including projects involving the milling off of a portion of the existing pavement prior to the laying down of new asphalt cement concrete layer(s), payment of the entire lump sum price for the item of "Mobilization," less the retainage provided for in Title 54-5-121, TCA, will be made with the first partial pay estimate paid on the contract, provided the amount bid for "Mobilization" does not exceed 5% of the total amount bid for the contract. When the amount bid for the item of "Mobilization" exceeds 5% of the total amount bid for the contract, 5% of the total amount bid for the contract will be paid on the first partial pay estimate, and the portion exceeding 5% will be paid on the last partial pay estimate.

722

SECTION 722-FIELD OFFICE

722.01 Description..... 647
722.02 Location 647
722.03 Minimum Spatial Requirements 647
722.04 Other Requirements 647
722.05 Outside Utilities..... 647
722.06 Interior Utility Services 648
722.07 Doors and Windows..... 648
722.08 Furnishings and Equipment 648
722.09 Concrete Cylinder Storage..... 649
722-10 Maintenance and Custodial Service..... 649
722.11 Project Sign 649
722.12-Basis of Pavement 649

SECTION 722- FIELD OFFICES

722.01 Description. This work shall consist of providing and maintaining an adequate, weatherproof field office for the exclusive use of the Engineer and his staff during both the contract period and for a maximum of 60 days hereafter, all in accordance with these Specifications.

GENERAL REQUIREMENTS.

722.02 Location. The field office or materials laboratory shall be located on a site that is both satisfactory to the Engineer and convenient to the project site.

722.03 Minimum Spatial Requirements. Unless specified otherwise in the Special Provisions of the Contract, the Engineer's field office shall contain a minimum of floor area and headroom as specified in the table below. It shall contain a sufficient number of windows to provide at least 27 square feet of natural light. Existing building structures meeting the above minimum requirements are considered acceptable.

| Building Type | Width | Length | Headroom | Windows Required |
|---------------|--------|--------|----------|------------------|
| Type 1 | 10 ft. | 30 ft. | 8 ft. | 6 |
| Type 2 | 12 ft. | 50 ft. | 8 ft. | 10 |

722.04 Other Requirements.

- a. The Contractor shall be responsible for arranging and complying with all necessary local and State regulatory permits and inspections, including all costs associated therewith.
- b. The Engineer's field office shall be fully equipped and ready for occupancy at least 2 days prior to the start of actual construction operations.
- c. The Contractor shall protect the field office and against fire, flooding, and theft throughout the 24 hours of every day the unit is in service. The Contractor shall be responsible for the loss of any property belonging to the Department that is housed therein due to theft, fire, or natural causes.

722.05 Outside Utilities.

- a. **Electrical Power.** The Contractor shall arrange for electrical service for the field office. The power supply shall be 115-volt, 60-cycle current of sufficient amperage to provide for heat, interior and exterior lighting, operating office equipment and air conditioning.
- b. **Sanitary Sewer Outfall.** The Contractor shall provide an adequate temporary outfall into either the municipal sanitary sewer system or an approved individual sewage disposal system. Disposal of sanitary

wastes must conform to the applicable requirements of the municipal regulations.

722.06 Interior Utility Services.

- a. Lighting.** Lighting fixtures as required to provide minimum illumination of 70 foot-candles in all areas.
- b. Electrical Receptacles.** Six duplex convenience electrical receptacles shall be located throughout the field office as directed by the Engineer. At least two of these receptacles shall be 20-amp capacity.
- c. Heating and Air Conditioning.** Heating and air conditioning equipment capable of maintaining a year round temperature between 70°F and 78°F shall be provided.
- d. Sanitary Facilities.** A water closet, lavatory, slop sink, vent fan, and a hot water heater of a minimum 5-gallon capacity shall be provided.
- e. Telephone, answering machine, and facsimile machine.** Telephone service with an answering machine, a facsimile machine and two incoming phone lines shall be provided.

722.07 Doors and Windows-Doors shall be stock sizes and shall have a key-in-knob lock of an approved manufacturer. All doors shall be keyed alike. All windows shall be operative except for picture windows. Operative windows shall be either double hung or casement type equipped with adequate locks. All windows shall be provided with either shades or Venetian blinds. All window openings shall be adequately screened. Windows in sanitary areas shall have frosted glass.

722.08 Furnishings and Equipment-The field office shall be provided with the following:

a. Furnishings.

1. Three office type desks, minimum top dimensions 32in. x 60in., with two or more drawers on each side.
2. Three swivel desk chairs.
3. One work table, 30 inches high, with a minimum of 24 square feet of work area.
4. One drafting stool.
5. Two folding-type chairs.
6. One fire resistant drawer-type safe, legal size, with combination or key lock.
7. One four-drawer legal size metal filing cabinet equipped with lock.
8. Two two-drawer (14½in. x 16in.) metal filing cabinets.
9. Two round wastebaskets.
10. One plan rack of an approved design to be equipped with 10 rods.

b. Equipment.

1. Two fully automatic electronic calculators with tape.
2. One office type copying machine.
3. One pencil sharpener.
4. A 5-pound CO₂ fire extinguisher of approved manufacture shall be furnished for each 200 ft² of floor area.

5. One First-Aid Kit.
6. One electric sanitary water cooler with refrigerated storage compartment; supply with paper cups.
7. Toilet paper holders, paper towel dispensers and soap dispensers in the toilet rooms, with a continuous supply of each.

722.09 Concrete Cylinder Storage-The Contractor shall provide a storage shed/building for temporary storage of concrete acceptance cylinders. The storage facility shall be of sufficient size and construction to protect the concrete cylinders from the elements and damage. The storage shed have a concrete curing box or water curing tank with a heating/circulating system of sufficient size to properly cure all acceptance cylinders before transferring for final storage and testing. The curing box or curing tank and heater/circulator shall comply with AASHTO M-201, and proper curing of the cylinders shall be in accordance with AASHTO T-23. A thermometer shall also be provided to assure proper curing temperatures.

722-10 Maintenance and Custodial Service-The Contractor shall provide the following maintenance and custodial services.

a. Maintenance. All necessary repairs of damaged, defective, or vandalized parts of the field office and associated furnishings and equipment shall be made. Maintenance operations shall continue as long as the field office is occupied by the Engineer.

b. Custodial

1. Weekly trash removal.
2. A broom and dust pan or bi-monthly floor cleaning service.
3. Cleaning supplies or bi-monthly window and sanitary facility cleaning.
4. Replacement of supplies as required to maintain office equipment and sanitary facilities.

722.11 Project Sign-Both the field office shall be equipped with a sign for the purpose of identifying the use of the structure and providing notice against trespassing.

COMPENSIION

722.12-Basis of Pavement--The field office shall be paid for as a lump sum item including all that is specified in this subsection of the specifications and shall be complete payment therefore for the duration of the project.

SECTION 730-TRAFFIC SIGNALS

| | |
|---|-----|
| 730.01-Description of Work | 651 |
| 730.02-Regulations and Code | 651 |
| 730.03-Submittal Data Requirements | 651 |
| 730.04-Mill Test Reports and Certification | 652 |
| 730.05-Working Drawings | 653 |
| 730.06-Guarantee | 653 |
| 730.07-Training | 653 |
| 730.08-Excavating and Backfilling | 654 |
| 730.09-Removing and Replacing Improvements | 654 |
| 730.10-Foundations | 655 |
| 730.11-Anchor Bolts | 655 |
| 730.12-Pull Boxes | 655 |
| 730.13-Transformer Base | 656 |
| 730.14-Conduit | 656 |
| 730.15-Conductors | 658 |
| 730.16-Cable | 658 |
| 730.17-Wiring | 658 |
| 730.18-Service Connection | 658 |
| 730.19-Sealant | 658 |
| 730.20-Strand Cable | 659 |
| 730.21-Bonding and Grounding | 659 |
| 730.22-Field Test | 659 |
| 730.23-Inspection | 659 |
| 730.24-Signal Heads | 660 |
| 730.25-Controllers | 663 |
| 730.26-Traffic Actuated Controllers | 669 |
| 730.27-Auxiliary Equipment for Traffic Actuated Controllers | 671 |
| 730.28-Flashing School Signals | 671 |
| 730.29-Detectors | 672 |
| 730.30-Coordination | 675 |
| 730.31-Time Base Coordination Units | 675 |
| 730.32-Cantilever Signal Supports | 678 |
| 730.33-Steel Strain Poles | 679 |
| 730.34-Pedestal Support Signal Poles | 680 |
| 730.35-Wooden Pole Signal Supports | 680 |
| 730.36-Pole Location | 681 |
| 730.37-Method of Measurement | 682 |
| 730.38-Basis of Payment | 687 |

SECTION 730-TRAFFIC SIGNALS

730.01-Description of Work. The work to be done consists of furnishing and installing all necessary materials and equipment to complete in place traffic signal systems and/or modifying existing systems, all as shown on Plans, standard or special details, and as set forth in these specifications. Unless otherwise indicated on the Plans or specified in the Special Provisions, all materials shall be new.

Where existing systems are to be modified, the existing material shall be incorporated into the revised system, salvaged, or abandoned as specified or as directed by the Engineer.

All incidental parts which are not shown on the Plans, or specified herein, and which are necessary to complete the traffic signal, or other electrical systems or required for modifying existing systems, shall be furnished and installed as though such parts were shown on the Plans or specified herein. Costs of such incidentals shall be included in bid price for other items. All systems shall be complete and in operation to the satisfaction of the Engineer at the time of completion of the work.

GENERAL REQUIREMENTS

730.02-Regulations and Code. All equipment provided shall conform to the standards of the **National Electrical Manufacturers Association(NEMA - Standards Publication, Traffic Control Systems**, latest revision) or the **Radio Manufacturers Association**, whichever is applicable. In addition to the requirements of these specifications, the Plans, and the Special Provisions, all material and work shall conform to the requirements of the **National Electrical Code**, hereinafter referred to as the Code; the **Standards of the American Society for Testing Materials(ASTM)**; the **American National Standards Institute(ANSI)**; U.S. Department of Transportation, Federal Highway Administration **Manual on Uniform Traffic Control Devices(MUTCD)**; **Institute of Traffic Engineers**; **International Municipal Signal Association, Inc.,(IMSA)**; and any other local ordinances which may apply.

Wherever reference is made to the Code, or the Standards mentioned above, the reference shall be construed to mean the code or standard that is in effect on the date of advertising the bids or authorization for force account.

730.03-Submittal Data Requirements. Within 30 days after the issuance of the work order, the Contractor shall submit to the Engineer, the Division of Materials and Tests and the local entity(city or county engineer), 1 collated set of the manufacturer's descriptive literature and technical data which fully describes the types of signal equipment he proposes to use. Descriptive literature shall include the manufacturer, models, etc. and be adequate to determine if the equipment or material meets the requirements of the Plans and these specifications. These sets of submittal data shall include a list of the materials submitted along with descriptive material for, but not limited to, the following items:

730

Controller
Cabinet and Exhaust Fan
Detectors
Signal Heads including Lamp Information and Mounting Hardware
Loop Wire and Loop Sealant
Shielded Detector Cable
Signal Cable
Cable for Span Wire, Guys, etc.
Pull Boxes
Conduit
Coordination Equipment

The submittal sets shall also include detailed scale drawings of any non-standard or special equipment and of any proposed deviation from the Plans. If requested to do so, the Contractor shall submit for approval sample articles of any materials proposed for use. The Department will not be liable for any materials purchased, labor performed, or delay to the work prior to such approval.

In addition to the above, the Contractor shall submit to the Engineer a notarized letter certifying that all traffic signal materials listed in the submittal are in conformance with the Plans and Specifications and a copy of a statement from the Maintaining Agency that the system is acceptable to the Agency.

Six prints of "Design" or "Shop" drawings indicating the proposed dimensions and material specification for each of the supports and mast arms involved shall be submitted by the Contractor to the Division of Structures for approval purposes within 30 days after the work order is issued. These drawings will be reviewed by the State at the earliest possible date and 2 prints will be returned "Approved for Fabrication", or "Returned for Revisions as Noted". Appropriate action shall be taken at this time by the Contractor to insure that the earliest possible correction of these items can be achieved so as not to delay the installation.

730.04-Mill Test Reports and Certification. Mill Test Reports or Certifications of Specifications for Materials and Design will be required for all materials incorporated into the work. The following shall be supplied by the Contractor prior to acceptance of the structures:

1. "Mill Test Reports"(M.T.R.) for MAJOR structural items only, as noted in Chart 1, shall include both physical and chemical descriptions of the material as supplied to the fabricator. When physical properties are altered during the fabrication M.T.R. covering chemical composition will be supplemented by certified test reports indicating the physical properties of this material after fabrication.
2. Certification of Conformance to the Specifications for all remaining material not covered by M.T.R. as noted in the Chart 1.

3. Certification that all welding was performed by operators qualified as follows: Steel welders to AWS and aluminum welders to ASME.
 4. Certification of Conformance to the Specification for the Design of all components not completely dimensioned and detailed on the "Standard" drawing.
-

CHART 1

| Component Materials | M.T.R. | Certification |
|--|--------|---------------|
| Tubes for arms and poles | X | |
| Base Castings | X | |
| Anchor Bolts | X | |
| Pole tops, misc. fittings and hardware | | X |
| Fabricated or cast-type arm connections | | X |
| Galvanizing | | X |

730.05-Working Drawings. The Contractor shall provide within the controller cabinet and to the local maintaining agency an electrical schematic diagram of the cabinet and system wiring. Manufacturer's instructions for installation, maintenance and operation of all equipment shall also be submitted to the local maintaining agency and placed within the controller cabinet. All materials placed in the cabinet shall be mounted in the cabinet inside a plastic envelope.

730.06-Guarantee. The Traffic Signal System(s) installed under these specifications, including all equipment, parts, and appurtenances in connection therewith shall be guaranteed to the City or County and State by the Contractor against defective workmanship and materials for a period of not less than 1 year following the date the signal system is made operational. except In no case shall this guarantee expire prior to 3 months after the final acceptance of the project. Upon completion of the project, warranties or guarantees on equipment and materials that are offered by the manufacturers as normal trade practice and have not expired shall be turned over by the Contractor to the government agency responsible for the maintenance of the signal installation.

730.07-Training. The Contractor shall provide to the maintaining agency a training session on the controller and associated cabinet equipment to be supplied on the project. The training session will last for a minimum 4 hours unless the maintaining agency determines a lesser time is adequate. The training shall be of a level to train the user in the complete operation and programming features of all controllers. The Contractor shall provide this training at a facility agreed upon by the maintaining agency. The Contractor shall provide the training prior to the acceptance of the project.

After the required training, the Contractor shall certify to the Engineer that training has been completed.

730

This training requirement shall not apply if a training program meeting these criteria has been accomplished by this vendor and/or manufacturer on the equipment being bid within 18 months previous to the date of this invitation to bid but shall apply if the bidder is proposing new, upgraded, or modified equipment not covered in such previous training program.

MATERIALS AND INSTALLATION

730.08-Excavating and Backfilling. The excavations required for the installation of conduit, foundations and other equipment shall be performed in such a manner as to cause the least possible damage to the streets, sidewalks, and other improvements. The trenches shall not be excavated wider than necessary for the proper installation of the electrical equipment and foundations. Excavating shall not be performed until immediately before installation of conduit and other equipment. The material from the excavation shall be placed in a position where the least disruption and obstruction to vehicular and pedestrian traffic will be realized and the least interference with the surface drainage will occur.

The excavations shall be backfilled and compacted to at least the density of the surrounding material. All surplus excavation material shall be removed and disposed of by the Contractor outside of the highway right-of-way, in accordance with these Specifications, or as directed by the Engineer.

Excavations, after backfilling, shall be kept well filled and maintained in a smooth and well-drained condition until permanent repairs can be made.

At the end of each day's work, and at all other times when construction operations are suspended, all equipment and other obstructions shall be removed from that portion of the roadway used by public traffic and parked a minimum of 30 ft.(9 m) from the edge of pavement unless otherwise protected by guardrail, bridge rail, or barriers installed for other purposes.

Excavation in the street or highway shall be performed in such a manner that not more than 1 traffic lane shall be restricted in either direction at any time. Traffic shall not be obstructed during hours of peak flow unless approved otherwise by the Engineer. Construction signing shall be incorporated in accordance with the Provisions of the **MUTCD**.

730.09-Removing and Replacing Improvements. Improvements, such as sidewalks, curbs, gutters, portland cement concrete and asphalt concrete pavement, bituminous surfacing, base material and any other improvements removed, broken or damaged by the Contractor, shall be replaced or reconstructed with the same kind of materials as found on the work.

The outline of all areas to be removed in portland cement concrete sidewalks and in all pavements shall be cut to a minimum depth of 2 in.(50 mm), with an abrasive type saw prior to removing the sidewalk and pavement material. Cut for remainder of the required depth may be any method satisfactory to the Engineer. Cuts shall be neat and true with no shatter outside the removal area.

Whenever a part of a square or slab of existing concrete sidewalk or driveway is broken or damaged the entire square or slab shall be removed and the concrete reconstructed as specified above.

All work shall be done in accordance with these Specifications, or any local ordinance which may apply, whichever is of a higher standard. Cost of this removal and replacement to be included in bid price for other contract items.

730.10-Foundations. Foundations for posts, standards and cabinets shall be Class A, portland cement concrete.

Foundations for posts, standards and pedestals shall be poured after the post, standard, pedestal, or anchor bolts or reinforcing steel is in proper position. The exposed portions shall be formed to present a neat appearance. The bottom of concrete foundations shall rest on firm undisturbed ground.

Forms shall be true to line and grade. Tops of footings for posts and standards, except special foundations, shall be finished to curb or sidewalk grade or as ordered by the Engineer. Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be placed by means of a template until the concrete sets. Both forms and ground which will be in contact with the concrete shall be thoroughly moistened before placing concrete. Forms shall not be removed until the concrete has cured for at least 12 hours and hardened sufficiently to allow firm removal without causing damage to the concrete.

Ordinary surface finish shall be applied to exposed surfaces of concrete. Wherever the edge of a concrete foundation or sidewalk section is within 18 in.(450 mm) of any existing concrete improvement, the sidewalk section shall be extended to meet said existing improvement.

Where obstructions prevent construction of planned foundations, the Contractor shall construct a foundation satisfactory to the Engineer.

730.11-Anchor Bolts. Anchor bolts meeting the requirements of AASHTO M 314, grade 55 or other high strength steel anchor bolts having a minimum yield strength of 55,000 p.s.i.(379 MPa) and a minimum ultimate strength of 90,000 p.s.i.(620 MPa) each fitted with one regular hex nut and one heavy duty square nut, shall be furnished with anchor-base type poles. All nuts and not less than 10 in. (250 mm) of the threaded ends of anchor bolts shall be hot-dip galvanized in accordance with ASTM A 153. The anchor bolts shall be capable of resisting at yield strength stress the bending moment of the shaft at its yield strength stress.

Plumbing of standards, posts and pedestals shall be accomplished by adjusting the nuts before the foundation is finished to final grade. Shims or similar devices for plumbing or raking will not be permitted. After plumbing or raking has been completed, anchor bolts will be cut off ¼ in.(6 mm) above the top nut and the exposed surface painted with rust protective paint.

Anchor bolts and nuts required for relocating existing standards and posts shall be furnished by the Contractor.

730.12-Pull Boxes. Pull boxes shall be constructed and installed as shown on the Plans and standard drawings or as directed by the Engineer. Additional pull boxes may be required where conduit runs are more than 150 ft.(45 m) long. Pull boxes shall be installed wherever practicable out of the line of traffic. Covers shall be level with the pavement, or with the curb or sidewalk grade, or with the surrounding ground as required.

Electrical conductors shall be placed within pull boxes in such a manner as to be clear of the metal frame and cover.

The bottom of the pull box shall rest firmly on a bed of crushed stone with a minimum depth of 12 in.(300 mm) below the bottom, and extending 6 in.(150 mm) beyond the outside edge of the pull box, unless otherwise specified by the Engineer.

Concrete pull boxes shall be constructed of a mixture of one part cement, two parts sand, and four parts gravel or 1 in.(25 mm) crushed stone with reinforcement placed as shown in the standard drawings. Reinforcement shall consist of steel wire fabric, 4 x 4 in.(100 x 100 mm) - No. 4/4@85 lbs/100 s.f.(4.2 kgs/m²), meeting the requirements of **Subsection 907.03**. Pull boxes may be poured in place or precast.

A cast iron frame and cover of dimensions shown in the drawings shall be installed in each pull box. Castings shall be class 30 and shall meet the requirements of **Subsection 908.07**. The covers shall have roughened top surface of 1/8 in.(3 mm) in relief. Notches shall be provided for removing the cover. The words "TRAFFIC SIGNALS" shall be inscribed on top of covers with letters 1-1/2 in.(38 mm) high and 1/8 in.(3 mm) in relief as indicated on the drawing.

The frame shall have a minimum weight of 42 lbs(19 kgs). The cover shall be of the "Extra Heavy" type with a minimum weight of 54 lbs(24.5 kgs).

Pull boxes other than concrete shall be composed of reinforced plastic or epoxy mortar and be designed and tested to temperatures of -50° F(-45° C), and meet the requirements of the following: ASTM D 756, ASTM D 543, ASTM D 570, ASTM D 790, and ASTM D 635 and shall be based on 30,000 lbs(13,610 kgs) single axle load over 10 x 20 in.(250 x 500 mm) area. The words "Traffic Signals" shall be inscribed on top of the covers.

730.13-Transformer Base. The transformer base shall be fabricated from steel plate and sheet and designed to harmonize with the shaft. Each transformer base shall be provided with: a 7-1/2 x 9 in.(187 x 225 mm), minimum handhole with cover secured with stainless steel fastening screws; 4 galvanized steel bearing plates to fasten the base to the anchor bolts; 4 galvanized steel bolts, nuts and washers to fasten base and standard; and a 1/2 in.(13 mm) - 13 UNC grounding nut welded to the inside of the base opposite the handhole opening. The strength of the transformer base shall be comparable with that of the shaft.

When transformer base is required, no handhole will be required in the shaft.

730.14-Conduit. Furnishing and installing plastic and steel conduit shall be in accordance with these specifications and close conformity with the lines shown on the Plans or as established by the Engineer.

Threads shall be clean cut, straight and true and of sufficient length to permit proper coupling; long running threads will not be permitted on any part of the work. Threads shall be protected in transit and during installation, and conduit shall be provided with proper supports and protection during construction to prevent injuries. All ends of pipe installed for future connections shall be properly threaded, reamed and capped to prevent water and foreign matter from entering the conduit system.

Sections shall be made up with red lead, so that ends of conduit will butt together. Threaded ends shall be provided with approved conduit bushings.

Signal conduit shall be 2 in.(50 mm) in diameter, and detector conduit 1 in.(25 mm) in diameter, unless otherwise indicated. Conduit for service connections shall be 1-1/4 in.(32 mm) in diameter. Conduits smaller than 1 in.(25 mm) diameter shall not be used unless otherwise specified, except grounding conductors at service points shall be enclosed in 1/2 in.(13 mm) diameter conduit. The Contractor may, at his own expense, use large size conduit, in which case it shall be for the entire length of the run with no reducing couplings permitted.

Materials - Types of conduits and fittings used shall be as follows:

1. Steel Conduit.
 - A. Rigid conduit and fittings shall be heavy-wall, hot dipped galvanized steel conforming to Federal Specification WW-C-581-d(3) and ANSI-C 80.1. It shall be galvanized inside and out and shall meet the requirements of ASTM A 53. Each length shall bear the label of Underwriters Laboratories, Inc.
 - B. Flexible conduit shall be galvanized flexible steel meeting Federal Specification WW-C-581-d(3), ANSI C-80.1 and UL Standard #6 with a minimum of 40 mils thickness of polyvinyl chloride coating conforming to ASTM D 746.
2. Plastic Conduit. Plastic conduit shall be high impact polyvinyl chloride(PVC), Schedule 40.

Installation - All bends shall be in strict compliance with the National Electric Code.

Conduits shall be laid to a depth of 6 in.(150 mm) below subgrade but not less than 24 in.(600 mm) below pavement grade except when approved by the Engineer; conduit may be laid at a depth of not less than 24 in.(600 mm) below top of curb when placed back of the curb. Conduit runs for detectors shall be parallel to existing or proposed curbs and not more than 18 in.(450 mm) behind the curb face unless otherwise specified. Steel conduit or Schedule 80 PVC conduit shall be placed under existing pavements by approved jacking or drilling methods. Pavements shall not be disturbed without the approval of the Engineer. Where trenching is allowed in a traffic bearing area, PVC conduit(Schedule 40) encased in concrete shall be used.

After installation of the conduit is completed, all conduits installed under this contract shall be tested with a mandrel having a diameter 1/4 in.(6 mm) smaller than the conduit and a length of 2 in.(50 mm). All conduits which will not allow passage of the mandrel shall be repaired to the satisfaction of the Engineer; if repairs cannot be affected the conduit shall be removed and replaced at no additional cost to the Department. After the mandrel test, all conduits shall be scoured with a stiff wire brush slightly larger in diameter than the conduit. The Contractors shall clear all conduits in the presence of the Engineer.

Conduits terminating in anchor base standards and pedestals shall extend approximately 2 in.(50 mm) above the foundation and shall be

730

sloped toward the hand-hole opening. Conduits shall enter concrete pull boxes from the bottom and shall terminate not less than 2 in.(50 mm) nor more than 4 in. (100 mm) above the bottom of the box and near the box walls to leave the major portion of the box clear.

Existing underground conduit to be incorporated into a new system shall be cleaned by blowing with compressed air, or by other means approved by the Engineer.

730.15-Conductors. Traffic Control Conductors shall be rated at 600 volts. All conductors, except loop conductors and cables run along messengers, shall be run in conduit except where run inside poles. Where signal conductors are run in lighting standards containing high voltage street lighting conductors, the signal conductors shall be encased in flexible or rigid metal conduit. Where telephone circuits are introduced into controller foundations, the telephone conductors shall be encased in flexible metal conduit, and shall also conform to regulations of the Code.

Conductors for traffic loops shall be continuous AWG No. 14(2.08 mm²) XLP stranded wire to the detector terminals or splice with shielded detector cable within a pull box, conduit or pole base.

Detector cable shall be 2 conductor twisted pair shielded AWG No. 14(2.08 mm²) stranded meeting IMSA Specification No. 19-2.

730.16-Cable. All signal cable shall conform to applicable IMSA Specification No. 19 or 20. Stranded cable color coded AWG #14(2.08 mm²) shall be used for all signal and accessory circuits. All circuit runs shall retain the same color identification throughout its entire length.

730.17-Wiring.

1. All wiring shall be terminated to screw terminals by means of lugs.
2. All splices shall be made with solderless connectors and shall be insulated with weatherproof tape applied to a thickness equal to the original insulation.
3. Cables shall be attached to messenger by means of non-corrosive lashing rods or stainless steel wire lashings.
4. All wiring within enclosed cabinets shall be neatly formed and harnessed and shall have sufficient length for access servicing.

730.18-Service Connection. Service connection details, metering, etc. shall be coordinated with the local utility as directed by the Engineer and shall conform to the City and/or County requirements. The Contractor shall be responsible for obtaining the necessary service for each installation.

730.19-Sealant. All sealant material shall be on the qualified products list maintained by the Department's Material and Test Division for sealing saw-cuts. It shall resist the upward movement of loop and lead-in and shall exhibit stable dielectric characteristics, including a low permittivity and high dielectric strength. It shall bond to the roadway paving material preventing entry of moisture and shall remain flexible without melting through all anticipated temperature and weather conditions.

730.20-Strand Cable. Span cable for suspending signal heads between pole supports shall be 7-strand, Class A, copper-covered steel wire strand, meeting the requirements of ASTM A 460, with a minimum breaking strength as noted in the Plans. An acceptable alternate is 7-strand steel wire with a Class A zinc coating meeting the requirements of ASTM A 475, with a minimum breaking strength as indicated in the Plans.

Strand cable for messenger wire use (other than span wire above) and for pole guy cable shall be of the diameter(s) indicated in the Plans and shall meet the requirements of ASTM A 475 for zinc-coated steel wire strand, 7-strand Siemens-Martin grade with a class A zinc coating.

A Figure 8 cable combining the messenger cable and conductor cable in an insulated jacket is an acceptable alternate to conductor cable lashed to a messenger cable.

730.21-Bonding and Grounding. Metallic cable sheaths, conduit, transformer bases, anchor bolts, and metal poles and pedestals shall be made mechanically and electrically secure to form a continuous system, and shall be effectively grounded. Bonding and grounding jumpers shall be copper wire or copper strap of not less than the same cross sectional area as No. 6 AWG (13.3 mm²).

A ground electrode shall be furnished and installed at each service point. Ground electrodes shall be one-piece lengths of copperweld ground rod not less than 8 ft. (2.4 m) in length and 1/2 in. (13 mm) in diameter, installed in accordance with the Code. Grounding of conduit and neutral shall be accomplished as required under the Code except that grounding conductors shall be No. 6 AWG (13.3 mm²) or approved equal, minimum. Exposed ground conductors shall be enclosed in 1/2 in. (13 mm) diameter conduit and shall be bonded to the electrode with a copperweld ground clamp.

730.22-Field Test. Prior to completion of the work, the Contractor shall cause the following tests to be made on all traffic signal and lighting circuits in the presence of the Engineer:

1. Test for ground in circuit.
2. A megger test on each circuit between the circuit and ground. The insulation resistance shall be not less than the values specified in Section 119 of the Code.
3. A functional test in which it is demonstrated that each and every part of the system functions as specified or intended herein.
4. All detector loops and leads shall be tested before and after they are sealed in the pavement to be sure there are no shorts to ground in the system and to assure that the loop plus lead-in inductance is within the operating range of the detector.

Any fault in any material or in any part of the installation revealed by these tests shall be replaced or repaired by the Contractor in a manner approved by the Engineer, and the same test shall be repeated until no fault appears.

730.23-Inspection. After completion of the installation and before final acceptance of the project a full operational check of the system under actual

traffic conditions shall be made as part of the inspection. The operational check shall cover a minimum time period of 30 calendar days. During this period the Contractor shall perform any necessary adjustments and replace any malfunctioning parts of the equipment required to place the system in an acceptable operational condition at no extra compensation. All work and materials to be performed or furnished under these specifications shall be subject to the direct supervision and inspection of the Engineer, and in all respects shall meet with his approval as conforming with the provisions and requirements prescribed herein. He and his authorized representatives, shall at all times be given free access to the work or any part thereof, and to any plant, yard, shop, mill or factory where, or in which, any article or material to be used or furnished in connection with such work is being prepared, fabricated or manufactured; and the Contractor will be required to provide every reasonable facility for obtaining full and sufficient information relative to the performance of the work and the character of materials, and for ascertaining that the quality of workmanship and materials is in accordance with the intent of these specifications.

The work shall be performed only in the presence of the Engineer or Inspector appointed by the Engineer, unless permission to do otherwise has first been obtained; and any thereof that is performed or constructed during the absence of Engineer or inspector, without such permission having been so granted, either expressly or by implication, will be subject to rejection.

The inspection of the work, however, shall not relieve the Contractor of any obligation to properly fulfill his contract as prescribed; and if the work or any part thereof, or any materials used in connection therewith, are found to be defective or unsuitable at any time prior to final acceptance, he will be required to forthwith make good or replace such defective or unsuitable work or material.

Application for an Engineer or Inspector in connection with work under these specifications shall be made by the Contractor at least 24 hours before the services thereof will be required.

SIGNAL HEADS

730.24-Signal Heads. Each vehicle signal head shall be of the adjustable, colored lens, vertical type with the number and type of lights detailed herein and as shown on the Plans; shall provide a light indicator in one direction only; shall be capable of adjustment(without attachments) through 360° about a vertical axis; and shall be mounted as shown on the Plans or as specified by the Engineer. The arrangement of the lenses in the signal faces shall be in accordance with Section 4B-9 of the **MUTCD**. All lenses shall be glass. All circular indications shall use 12 in.(300 mm) lenses unless otherwise shown on the Plans. All arrow indications shall use 12 in.(300 mm) lenses. All new vehicle signal heads installed at any one intersection shall be of the same style and from the same manufacturer. All signal heads, signal head mountings, and outside of hoods shall have 1 or more coats of primer followed by 2 coats of high quality synthetic resin enamel of Traffic Signal Yellow and shall meet or exceed Federal Specifications TTC-595 Gloss Yellow.

Louvers as specified, interior of signal hoods, and back plates shall have 1 or more coats of primer followed by two coats of Lusterless Black

Enamel meeting or exceeding Federal Specifications TT-E-489. All factory enameled equipment and materials shall be examined for damaged paint after installation, and such damaged surfaces shall be repainted to the satisfaction of the Engineer. Factory applied enamel finish in good condition and of appropriate color will be acceptable.

Suspensions for span wire mounting of multi-faced signal heads and signal head clusters (such as a 5-section signal head) shall include an approved swivel type balance adjuster for proper vertical alignment.

Signal heads shall be fabricated from die-cast bodies. Sand castings will not be acceptable.

All signal heads must meet the minimum requirements for adjustable face vehicle traffic control signal heads as specified in ITE Technical Report No. 1(1970) and its latest revision.

In addition to these standards the following will be applicable:

Optical Units - Signal lamps for 8 in.(200 mm) lenses shall be clear, 595 rated initial lumen output, with a minimum life of 6,000 hours. Signal lamps for 12 in.(300 mm) lenses shall be clear, 1750 rated initial lumen output, with a minimum life of 6,000 hours.

Signal Head Mounting and Mounting Brackets - Signal heads shall have either integral serrations or shall be equipped with positive lock rings and fittings designed to prevent heads from turning due to external forces. Lock ring and connecting fittings shall have serrated contacts. Signals shall be provided with water-tight fittings using neoprene washers.

Bracket mounted signal heads, as shown on the Plans, shall be supported by mounting brackets consisting of assemblies of 1-1/2 in.(38 mm) standard pipe size. All members shall be either plumb or level, symmetrically arranged, and securely assembled. Construction shall be such that all conductors are concealed within poles and mounting assembly. Each slip fitter shall be secured to the pole.

Directional Louvers - Where shown on the Plans, louvers shall be furnished and installed in the hoods of the signal head sections designated.

Directional louvers shall be so constructed as to have a snug fit in the signal hoods. The outside cylinder and vanes shall be constructed of a non-ferrous metal or galvanized sheet steel. Louvers shall be painted with two coats of black enamel as specified in these specifications.

Backplates - Where shown on the Plans, back plates shall be furnished and attached to the signal heads. All back plates shall be louvered and constructed of 3,003, half-hard, 0.051 in.(1.30 mm) minimum thickness aluminum sheet. Other materials such as plastic or fiberglass shall be permitted where approved. In fabricating back plates, the inside vertical edges, adjacent to the signal head, shall be bent back forming mounting brackets for attaching to the signal. Back plates are to be formed in two or more sections and bolted together, thus permitting installation after signal heads are in place. Back plates shall have a dull black appearance.

Wiring - Signal head leads shall be No. 18 AWG(0.82 mm²) stranded with 221° F(105° C) Thermoplastic insulation. A separate white(common) lead shall be wired to each socket shell; and a colored lead, corresponding to the

color code specified in the Plans, shall be wired to each socket terminal. Leads shall be of sufficient length to allow connection to the terminal block specified herein. Each complete signal head shall be provided with a minimum 4-point terminal block, properly mounted in a signal section. Stud type terminal blocks shall have not less than ¼ in.(6 mm) edge clearance to any portion of the stud. Exterior wiring shall have a 360° drip loop in advance of entering the head.

Pedestrian Signals - When shown on the Plans, pedestrian signals shall conform to the following:

1. Pedestrian indications should attract the attention of and be readable to the pedestrian both day and night and at all distances from 10 ft.(3 m) to the full width of the area to be crossed.
2. All pedestrian indications shall be rectangular in shape and shall consist of the lettered messages WALK and DON'T WALK. For the purposes of these specifications the messages WALK and DON'T WALK shall be interpreted to be equivalent to the international symbols of a "Walking Figure" and "Upraised Hand", respectively.
3. When illuminated, the WALK indication shall be lunar white meeting the standards of the institute of Traffic Engineers. All except the letters shall be obscured by an opaque material.
4. When illuminated, the DON'T WALK indication shall be Portland orange meeting the standards of the Institute of Traffic Engineers with all except the letters obscured by an opaque material.
5. When not illuminated, the WALK and DON'T WALK messages shall not be distinguishable by pedestrians at the far end of the crosswalk they control.
6. The letters shall be at least 3 in.(75 mm) high for crossing where the distance from the near curb to the pedestrian signal indication is 60 ft.(18 m) or less. For distances, over 60 ft.(18 m), the letters shall be at least 4-1/2 in.(114 mm) high.
7. The light source shall be designed and constructed so that in case of an electrical or mechanical failure of the word DON'T, the word WALK of the DON'T WALK message will also remain dark.

Each section shall be provided with a visor encompassing the top and sides of the signal face of a size and shape adequate to shield the lens from external light sources. Lamps shall be 69 watt traffic signal type.

The housing door, door latch, and hinges shall be of aluminum, or approved equal. Hinge pins shall be stainless steel. The door shall be provided with a neoprene gasket capable of making a weather resistant, dust-proof seal when closed.

All pedestrian signal heads, mountings, outside of hoods, and pedestrian push button housings shall have 1 or more coats of primer followed by 2 coats of high quality synthetic resin enamel of Traffic Signal Yellow and shall meet or exceed Federal Specifications TTC-595 Gloss Yellow. The interior of signal hoods shall have 1 or more coats of primer followed by 2 coats of Lusterless Black Enamel meeting or exceeding Federal Specifications TT-E-489. All factory enameled equipment and

materials shall be examined for damaged paint after installation, and such damaged surfaces shall be repainted to the satisfaction of the Engineer. Factory applied enamel finish in good condition and of appropriate color will be acceptable.

Signal Head Installation - Signal heads shall be installed with the faces completely covered until the entire installation is ready for operation.

CONTROLLERS - GENERAL

730.25-Controllers. A controller shall consist of complete electrical mechanism for controlling the operations of traffic control signals, including the timing mechanism and necessary auxiliary equipment, mounted in a cabinet.

Interval Sequence - The color sequence of signal indications shall be green, yellow and red. Overlaps, such as green and yellow indications showing at the same time will not be permitted. During any interval there shall be no visual flicker of signal indications. Under no conditions whatever, shall controllers allow conflicting green signal indications to be displayed.

Flashing Operations - All controllers shall be equipped to permit any combination of flashing red and/or yellow lights. However, flashing operation shall be set for flashing yellow lights on the main street or highway unless otherwise specified in the Special Provisions, shown on the Plans, or directed by the Engineer. The flashing mechanism shall produce between 50 and 60 flashes per minute through two 120 volt, 15 ampere circuits. One illuminated period at each flash shall not be less than 1/2 and not more than 2/3 of the total cycle.

Pedestrian signals shall be dark during flashing operations. During normal operation pedestrian signals shall flash "DON'T WALK" during the pedestrian clearance interval.

Two circuit solid state flashers shall be used unless otherwise specified.

Wiring Diagrams - A schematic wiring diagram of the controllers and auxiliary equipment shall be submitted at the time the controllers are delivered, or previous to ordering if requested by the Engineer. This diagram shall show in detail all circuits and parts. Such parts shown thereon shall be identified by name or number and in such a manner as to be readily interpreted.

Operating Line Voltage - All equipment shall be designed to operate from a 120 volt, 60 cycle AC supply. Operation shall be satisfactory at voltages from 105 to 130. All operating voltages into and out of the controller shall be NEMA level D.C. voltages, except for A.C. power (connector A, pin p and U).

Lightning Protectors and Interference Suppressors - Ample lightning protectors to provide effective defense against high transient voltages caused by lightning discharges or other sources shall be provided. Each controller cabinet must be furnished with the following surge protection devices:

1. Main power suppressor for all but flasher or remote detector cabinets shall have the following characteristics:
 - A. Peak surge current 20,000 Amperes
 - B. Clamp Voltage 250 Volt
 - C. Response Time Voltage NEVER exceeds 250 Volts
 - D. Continuous Current 10 AMPS at 120 VOLTS AC
2. Power Protector for Controller Flasher, Flashing Beacon, and Remote Detector Cabinets:
 - A. Peak Current 15,000 Amperes
 - B. Power Dissipation 15 Watts
 - C. Peak Voltage 212 Volts
3. Loop Detector Input Terminals shall be provided with the following devices:
 - A. Peak Surge Current 400 Amps Differential Mode
1,000 Amps Common Mode
 - B. Response Time 40 Nanoseconds
 - C. Input Capacitance 35 pf typical
 - D. Clamp Voltage 30 Volts Max(either mode)
4. Auxiliary Relays and Fan shall be provided with a resistor/Capacitor circuit to suppress generated noise.
5. RF Filter shall be provided in controller cabinets and shall provide filtering of RF noise over the range of 60 hertz through 20 Megahertz. The RF filter may be incorporated as part of the Main Power Suppressor.

Controller Cabinets - Controller shall be housed in a rigid, weatherproof cabinet, constructed, finished and equipped as follows, and as shown on the Standard Details.

1. Material - All cabinets shall be of weathertight construction fabricated from aluminum sheet or cast aluminum alloy minimum 0.125 in.(3 mm) thickness. Painting of cabinets is not required unless the final finish presents an unsightly appearance.
2. Doors - Type III, IV, and V cabinets shall have a hinged front opening door which shall include substantially the full area of the front of the cabinet. The door shall be equipped with a positive hold fast device to secure the door in at least two open positions; one position at approximately 90 degrees and the other at 120 degrees or more. The holdfast device shall be easily secured and released without the use of tools. Doors for Type II, III, IV and V cabinets shall also be equipped with a switch compartment and the manual switches, specified in this section, shall be provided with a

hinged front opening auxiliary door. Each door shall have a gasket to provide a weatherproof seal when closed.

Main door shall have No. 2 pin-tumbler cylinder lock. Auxiliary door shall have a standard police sub-treasury lock. Four keys for each lock shall be provided.

3. Cabinet mounting shall be as shown on the Plans or standard details.
4. Ventilation - Unless otherwise specified, ventilation shall be provided as follows:

All cabinets housing controllers shall have a screened raintight vent 1-1/2 in.(38 mm) in diameter, or larger, mounted on the cabinet top.

Inlet ventilation openings shall be screened or filtered openings, equal to or greater in area than top vents, located in the bottom or lower back side of Type I and II cabinets or around the lower 8 in.(200 mm) portion of Type III cabinets.

Vents shall be so constructed as to project within cabinet no more than necessary to provide for lock nuts and gaskets to retain the vent, and shall be so located as to not interfere with the mounting of controller equipment.

5. Cabinets provided with "Exhaust Fans" - Exhaust fans shall consist of an electric fan with ball or roller bearings and a capacity of at least 100 c.f.(3 m³) per minute. The fan shall be mounted in a raintight housing attached to the top of the controller cabinet.

The fan shall be controlled by a thermostat having a temperature differential between turn-on and turn-off of 15° F(-0, +5° F)(8° C(-0, + 3° C)), adjustable for turn-on through a minimum calibrated range of from 100° to 150° F(38 to 65° C).

Whenever a fan is to be installed, the air inlet filter, and filter holder shown in the Standard Details, or approved equal, shall be provided. Any other air inlet shall be internally sealed. Exhaust fans are required in all cabinets which house controllers, with the exception of flasher controllers.

6. Auxiliary Equipment - Excepting cabinets used in special applications(Type 1 and 11), all cabinets shall be fitted with the following:

- A. Substantial shelves or brackets shall be provided to support controller and auxiliary equipment.

- B. The panel for terminals shall be arranged for adequate electrical clearance.

- C. Control panel assembly consisting of:

1. The power supply connections shall be made to a 30 ampere circuit breaker mounted on the cabinet separate from the signal terminal panel. The circuit breaker shall be a magnetic trip type, having an interrupting capacity of at least 2,000 amperes at 125 volts AC. The circuit shall trip between 101 and 125 percent of rated load, with an inverse time delay characteristic provided. Instantaneous tripping shall occur at ten times the nominal rating. All controllers shall be internally fused.

2. Service Line Surge Protection.
 3. Electrical Service termination point shall be sized to accept copperwire sized up to #4 AWG(21.2 mm²).
 4. Ground Fault Receptacle.
 5. Porcelain lamp receptacle to accept a standard traffic signal lamp.
 6. Circuit Breakers for:
 - a. Main Power Input to provide all power associated with normal operation.
 - b. Flasher Power Input to provide all Power associated with Flash operation.
 - c. service power to provide Power for the lamp and duplex receptacle.
 7. Copper Ground Buss(minimum of 12 positions).
- D. Flasher mechanism independent of controller.
- E. Where required to perform specified functions general purpose relays shall be provided.
- F. Type II, III, IV and V cabinets shall also be provided with, when specified as housing for traffic actuated controllers, two or more insulated terminal blocks mounted within the housing, one or more for terminating each field wire.
- G. A minimum of 12 available bare ground positions tied to AC Common Return.
- H. Earth(driven) ground tie point to terminate a single #4 AWG(21.2 mm²) copper ground.
- I. Tie point to tie all ground systems within the cabinet to a single reference point. All grounds(AC - return, Chassis, and Logic Ground) must be referenced to a single ground point at the electric service. A panel behind the auxiliary door to contain the following switches:
1. A main power switch, which shall be wired to remove all cabinet power when in the Off position
 2. An Automatic Flash switch, which shall be wired as follows:
 - a. When in the Flash position, shall cause the cabinet to provide Flash Operation. The controller shall continue to operate, and Stop Time shall be applied to the controller.
 - b. Upon return from Flashing to Automatic, the controller shall initialize in the Start-Up Display condition. This display, unless noted otherwise shall be Green for the Artery phase(s).
 3. A panel mounted inside the main door to contain the following switches:

- a. A technician Stop-Time switch to apply Stop Time to each controller ring.
- b. An Interval Advance switch, enabled only by the Stop Time switch, to be momentary pushbutton switch to apply Interval advance to the timer.
- c. A Signal On-Off switch which will remove the AC power applied to the signal heads for normal operation while the controller continues to operate.
- d. Individual phase vehicle and pedestrian detector test switches to be miniature toggle of the On-Off Momentary type to place:
 - i. No Call - Call provided by detectors.
 - ii. Locked detector call.
 - iii. Momentary detector call.

Switch terminals on back of main cabinet door shall be insulated or shielded so that no live parts are exposed.

Leads from the terminal block to the auxiliary door switches shall be no less than No. 18 AWG(0.82 mm²) stranded, with TW plasticized polyvinyl chloride or nylon insulation enclosed in an insulating loom and shall be of sufficient length to permit full opening of the main cabinet door.

- J. The cabinet shall be wired according to the following:
 1. Four phase controllers shall be wired for 4 vehicle phases, 2 pedestrian phases and 2 overlaps. Eight NEMA load switch bases shall be included per cabinet.
 2. Eight phase controllers shall be wired for 8 vehicle movements, 4 pedestrian phases and 4 overlaps. Twelve NEMA load switch bases shall be provided.
- K. All cabinets shall be supplied with a Signal Conflict Monitor(SCM) which meets the NEMA Standards. The SCM for all controller cabinets with 3 or more phases shall be the 12-channel type, and shall have the following features:
 1. Liquid Crystal Display to show all data in English language format.
 2. Shall monitor all Green/Yellow/Red/Walk field display outputs.
 3. Shall monitor the Controller 24 VDC output and be user programmable to have this monitor function Latch on.
 4. Shall monitor the Controller Voltage Monitor output, and be user programmable to have this monitor function Latch On.
 5. Per Channel monitoring of Phase Yellow Clearance Interval, and shall cause flash operation if Yellow

Clearance is less than the SCM programmed time(2.7 - 9 seconds).

6. Front panel mounted over-current protection(no internally mounted fuses are acceptable).
7. Front panel mounted reset switch.
8. Fault logging features:
The SCM shall log all faults as to the:
 - a. Date of fault
 - b. Time of fault
 - c. The fault condition
 - d. Power failure

and store these fault conditions in no-volatile memory for user retrieval. The monitor shall be able to store at least 10 such faults. The internal time clock shall automatically adjust for Daylight Savings Time changes. There shall be a keyboard method for the user to display and clear the stored event log.

9. There shall be an RS-232 port on the SCM to allow the user to print all data stored in the SCM. The printer shall interface with the SCM via a standard RS-232 cable. Printer to be supplied by others.
 10. The SCM shall detect the following conditions and place the cabinet in the flash mode by De-energizing the Flash Transfer Relays:
 - a. Absence of an active AC input on a channel
 - b. Green/Yellow both active on a channel
 - c. Yellow/Red both active on a channel
 - d. Green/Red both active on a channel
 - e. Green/Green active on conflicting channels
 - f. Green/Yellow active on conflicting channels
 - g. Green/Walk active on conflicting channels
 - h. Low 24 VDC sample
 - i. Controller Voltage Monitor active
 - j. Clearance time less than programmed
 11. On circuits where all field outputs are not used(such as left-turn phases) unused circuits shall be terminated at a load resistor and the monitor plus features shall function
 12. No functional field display shall be permitted unless monitored by the SCM
 13. The SCM sampling inputs shall be terminated at the closest tie point to the field termination
7. When called for in the Plans, or special provisions, certain enhanced operational features of controllers are to be supplied. When required, these inputs and outputs shall be accessed to the controller by a dedicated fourth(or "D" Connector) This

connector shall be of a type as determined by the manufacturer, but shall meet the following requirements:

- A. This connector shall not be mateable to any other connector in the cabinet.
- B. All operating voltages in this connector shall be NEMA DC level voltages.
- C. No special operating features shall enter or exit the controller on any NEMA pin designated as "Spare" or "Future".
- D. When the "D" connector is not connected to the controller, the cabinet facility shall operate as a standard NEMA cabinet facility with no operational loss of standard NEMA features.
- E. If the "D" connector is utilized as the input source for Pre-Emption operation, the cabinet facility shall be wired in such a manner that the cabinet facility will NOT perform any operation other than FLASH unless the "D" connector is terminated at the correct termination point and all cabinet features including Pre-Emption are operational.

TRAFFIC ACTUATED CONTROLLERS

730.26-Traffic Actuated Controllers. The controller mechanism shall meet or exceed the current NEMA Traffic Signal Systems Standard. Standard A, B and C Connectors are to provided. The vendor shall submit private laboratory certification that the proposed unit is in complete compliance with the NEMA standards in effect at the time of the advertisement for bids.

The controller shall have all timing values entered via a front panel mounted keyboard. This keyboard shall be an integral part of the controller unit.

Each controller shall have all operating timing parameters as specified in NEMA on a per phase basis, including all Volume/Density features. Each phase shall have a defeatable Last Car Passage feature wherein the last vehicle receiving the Phase Green shall receive at least one full Passage Time increment.

The controller shall have all of the following keyboard entered values or parameters:

1. Start on condition of the controller where the user can select via the keyboard the following:
 - A. Phases to start in.
 - B. Phase display to be on.
 - C. Overlap display start-on condition.
 - D. Normal start-up display shall be mainstreet green phase(s), with concurrent overlaps green.
2. Phase recall functions.
 - A. Non-lock detector.
 - B. Lock detector Call.
 - C. Minimum recall.

730

- D. Maximum recall.
 - E. Pedestrian recall.
 - F. Non-actuated phase.
 - G. Phase not active, phase omitted.
 - H. Pedestrian phase omitted.
3. All phase interval timing values except the Phase Yellow Clearance shall be as per NEMA. Each controller phase Yellow Clearance Interval is 3.0 seconds as a minimum.

The controller shall have a back-lit liquid crystal display for each ring of the controller to provide an English language menu for programming with displays for programming or reading all controller features. The dynamic displays for real-time operation shall be able to display the following values for each ring or phase(s) concurrently:

- 1. Per Phase Display:
 - A. Phase Vehicle Call.
 - B. Phase Pedestrian Call.
 - C. Phase is Next In Service.
 - D. Phase is In Service.
 - E. Phase Pedestrian Intervals in Service.
- 2. Per Ring Display:
 - A. Ring Gapped Out.
 - B. Ring Maximum Green Termination.
 - C. Ring was Force Off Terminated.
 - D. Ring Maximum Green II in effect.
 - E. Ring Phase in Service Operating:
 - 1. Lock Call.
 - 2. Non-Lock Call.
 - 3. Minimum Recall.
 - 4. Maximum Recall.
 - 5. Pedestrian Recall.
 - 6. Non-Actuated Mode.
- 3. Per Ring Display of Timing Values(Real Time). The following values shall be selectably displayed and shall display the current value in a real time mode.
 - A. Minimum Green Interval.
 - B. Passage Timer.
 - C. Pedestrian Interval Timing.
 - D. Maximum Green Timer.
 - E. Time Before Reduction Timer.
 - F. Time to Reduce Timer.

It shall be possible to inspect and alter any currently programmed value while the controller is in operation without affecting the field operation. The controller shall continue to operate the intersection as values are inspected or altered.

All operator entered data shall be stored in EEPROM devices which require no battery to support value storage. No internal components of circuitry shall require battery support.

The timer shall have a front-panel mounted RS-232 connector to allow the user to print a hard copy of all programmed data to a standard serial printer. The printer shall use a standard RS-232 connecting cable. Printer to be supplied by others.

730.27-Auxiliary Equipment for Traffic Actuated Controllers. The following auxiliary equipment shall be furnished and installed in each cabinet for traffic actuated controllers.

Load Switches - Each cabinet shall be provided complete, with the necessary number of **NEMA** load switches and Flash Transfer relays necessary to effect the specified signal sequence and phasing. Load switches shall meet the following requirements:

1. Shall meet **NEMA** Standards.
2. Shall have front-face mounted LED indicators to indicate the "On" condition of both the Input and Output circuits.
3. Shall utilize replaceable "cube" type circuitry or encapsulated discrete component construction. No unencapsulated discrete component construction shall be acceptable.

Time Clock Switches - Where specified in the Plans, time clock switches shall be of solid state circuitry, continuous duty, with a 7 day cycle clock operating from the 120 VAC service line. Switching shall be provided for a minimum of one independent outputs and the time of day selection shall be adjustable to within 1 minute of the desired time. A battery back up system shall be provided which can maintain time keeping and memory a minimum of 24 hours after power interruption. An omitting device shall be furnished as an integral part of the time switch to enable the switching operation to be skipped for any preselected day or days of the week. The time clock shall automatically compensate for daylight savings time changes. When the time clock is supplied as an internal component of the controller, the clock feature shall be supplied to provide for the selection of Maximum Green II on time of day, day of week, week of year basis. Time clocks shall meet NEMA environmental specifications.

FLASHING SCHOOL SIGNALS

730.28-Flashing School Signals. When shown on the Plans, flashing school signals shall conform to the following:

1. The signal shall produce 2 alternate flashing lights within the marginal limits of a school speed limit sign. Details of the sign construction shall be as specified on the Plans. Sign colors shall

conform to the **MUTCD** and be constructed of materials complying with these specifications.

2. The 2 lenses shall be yellow in color and a minimum of 8 in.(200 mm) in diameter. They shall be mounted in the sign using a molded endless rubber gasket with the sign being mounted to the signal case. The reflector for the round lens shall be glass and firmly mounted between the lens assembly and the case so as to produce a weather-proof and water-tight optical unit.
3. The flasher unit shall be the 2 circuit type to provide alternating equal on-off operation. The flashing mechanism shall produce between 50 and 60 flashes per minute through two 120-volt, 60-cycle AC, 15 ampere circuits. The flasher shall be of solid state construction.
4. The unit shall be wired for external circuits.
5. The signal shall be actuated by time switch, meeting the specifications of **Subsection 730.27**. The timing device shall be located in a remote mounted control cabinet.
6. Where an illuminated speed limit indication is specified on the Plans, the numeral message shall be illuminated in Portland Orange in a rectangular lens and illuminated only during the period when the signal produces two alternately flashing amber lights.

DETECTORS

730.29-Detectors. Detectors shall be used for actuating signal phases of traffic actuated controllers and shall be of the type specified in the Plans. Ample lightning protection to provide effective defense against high transient voltages caused by lightning discharges or from other sources shall be provided. The lightning protection unit must withstand repeated 400 ampere surges on an 9 x 20 microsecond waveform. Also, the unit must be 2 stage device capable of clamping a minimum of(100) 300 ampere surges to 25 volts within 40 nanoseconds. Surge applied across the 2 detector leads.

Inductive Loop Detectors - Loop amplifiers shall be of the single-channel, totally self-contained type, utilizing a standard 10-pin MS connector(MS3102-A-18P) and designed to operate within the **NEMA** environmental standards. All loop amplifiers shall be of the type to provide both "Extended" and "Delayed" outputs. Loop amplifiers shall have the following operational characteristics.

The loop detector amplifier shall be full automatic, requiring no adjustments to effect operational ability other than setting of the operating frequency and sensitivity. The amplifier shall have the following characteristics:

1. Shall sense any legal motor vehicle traveling at speeds up to 65 mph(105 kph).
2. Shall have both a "Pulse" and Presence" Output:

- A. Pulse output shall generate an output of 125 ± 25 millisecond output for each vehicle entry.
 - B. Presence output shall provide a continuous output for up to 60 minutes as long as a vehicle is within the detection zone.
3. Shall provide at least 4 user selectable sensitivity ranges .
 4. Shall be supplied with at least 3 frequency ranges for crosstalk minimization.
 5. Shall have a front-face mounted indicator to indicate active output of the internal relay. This indicator shall indicate the presence of:
 - A. Normal Output
 - B. Delayed Output
 - C. Extended Output
 6. Shall have a front-panel mounted "Reset" switch, which when pressed shall cause the unit to completely re-tune itself.
 7. Shall have Delayed or Extended timing features with the following ranges:
 - A. Delayed output of 0-30 seconds in 1-second increments.
 - B. Extended output of 0-10 seconds in 1/4 second increments.
 8. Shall have internal diagnostics to determine the operational ability of the loop. These diagnostics shall determine if a loop is opened or shorted, and shall provide a visible indication of such condition. Additionally, if such a condition occurs the amplifier unit shall default to a "constant" output.
 9. Output shall be by a mechanical relay, which shall be "off" to provide an output.
 10. All delay functions shall be wired to the associated plan phase green to inhibit that function during controller phase green.
 11. Shall be able to operate with loop lead-in lengths of at least 2,000 ft.(600 m).

The details of the detector loop installation are specified in the Plans or standard drawings.

Pedestrian Push Buttons - Where shown on the Plans, pedestrian push buttons of substantial tamper-proof construction shall be furnished and installed. They shall consist of a direct push type button and single momentary contact switch in a cast metal housing. Operating voltage for pedestrian push buttons shall not exceed 24 volts.

The assembly shall be weatherproof and so constructed that it will be impossible to receive an electrical shock under any weather condition.

Where a pedestrian push button is attached to a pole, the housing shall be shaped to fit the curvature of the standard or post to which it is attached to provide a rigid installation.

Unless otherwise specified, push button and sign shall be installed on the crosswalk side of the pole.

Magnetometer Detectors - The magnetometer detector shall be capable of being activated by a change in magnetic field caused by the presence or passage of a vehicle within the lane of required detection at any speed from 0 to 80 mph (0 to 130 kph). The term "magnetometer detector" applies to a complete installation consisting of a sensing element or group of sensing elements installed in the roadway as shown on the Plans, lead-in cable, and a control unit with power supply installed in a traffic signal controller cabinet or special cabinet as specified on the Plans.

The sensing elements shall be no larger than 2 in. (50 mm) in diameter by 4 in. (100 mm) high and shall contain no moving parts or transistors.

The control unit shall be an electronic device capable of providing closure of an output circuit when a vehicle stands over or passes through the magnetic field of the sensing elements connected to the input circuitry of the control unit. The output shall be electrically insulated from the sensing element and the electronic circuitry.

Each detector shall operate from a 120-volt, 60 hz, AC supply. Operation shall be satisfactory at voltages from 110 to 130. In addition, the unit shall not be affected by normal powerline transients or by powerline voltage variations of plus/minus 10%.

The control unit for the magnetometer detector shall be designed for either (1) permanent presence (2) pulse presence or (3) presence counting of vehicles or combinations thereof.

The permanent presence control unit shall signal continually the presence of any vehicle until the vehicle leaves the area of detection, where upon the vehicle signal shall immediately drop.

The pulse presence control unit shall provide one x 30 millisecond, plus/minus 10%, pulse for every vehicle entering the area of detection.

The presence counting control unit signal shall provide separate detection of each distinct traffic lane.

Each control unit shall have solid state circuitry, except for the output relay; and shall be housed in control box. Each control unit shall be furnished with an integral power supply. Each control unit shall be designed to provide ease of maintenance. All electronic components shall be easily accessible.

Calibration of the control unit shall be accomplished with tuning controls.

Each detector shall provide positive vehicle detection without readjustment from minus 20° to +160° F (-30° C to +70° C).

All controls, pilot lights, meters, fuse-holders, and connectors shall be mounted on the front panel of the control unit or the control power source assembly. Input power shall be fused.

When control unit and power supply components are mounted on insulating boards, printed circuit wiring may be used. Printed circuit boards shall be designed to facilitate identification of components. This shall be done by either part identification markings or by providing a pictorial diagram showing physical location and identification of each component.

The sensing elements shall be placed in holes cut in the roadway at locations shown on the Plans. Each hole shall be large enough to accept a 2 in. (50 mm) diameter sensing element and shall be 8 in. ±2 in. (200 mm ±50 mm) deep. The holes shall be vertical, regardless of the slope or grade of the pavement surface.

COORDINATION

730.30-Coordination. The following are minimum design and operating requirements for all types of local coordinating units. The general design requirements apply to master coordinating units and secondary coordinating units; as a separate unit or internal to the controller; both dial electro-mechanical, and digital full solid state. Local coordinating units provided for an interconnected signal system shall be completely compatible with the master controller and all local controllers in that system.

The coordinating units described herein shall be used in conjunction with solid state traffic actuated signal controllers and traffic adjusted master controllers. The coordinators shall inhibit the external extension limit in the local controllers and provide external maximum control. Background cycle lengths, splits, system offsets and other coordination functions as required shall be called in by a master controller or coordinator. These functions may also be called in by local or master override or time switches.

All coordinating units shall be furnished capable of at least the following:

1. Three background time cycles.
2. Three splits per cycle.
3. Three offsets per cycle.
4. Multiple and adjustable permissive periods for yielding to non-coordinated phases.
5. Force off capability for all non-coordinated phases.
6. Capability of generating as a minimum cycle lengths of 50, 60, 70, 80, 90, 100 and 120 seconds.
7. Master intersection control and supervision of other coordinating units as required.
8. Free operation when called for by the system master, time switch, or manual override.

It shall be possible to set offset splits, and all synchronization functions from the front of the coordinating unit. It shall be possible to make these settings in at least 1 percent steps to any percentage of the associated cycle length.

Absence or conflict of offset or cycle information on the interconnect shall place the coordinating unit in cycle number 1(average offset) or a preset standby cycle.

730.31-Time Base Coordination Units. This section covers traffic signal system time based coordination units of solid state design. Time based coordination units are used to control the timed relationship between intersections to maintain a system interconnect plan without the use of interconnect cable.

Background Cycle. Time based coordination units shall be provided with at least 3 independently programmable background cycles. The background cycles shall be in fixed increments, which do not exceed 1 second.

730

Offsets. Time based coordination units shall be provided with at least 3 independently programmable offsets per background cycle.

Splits. Each split shall have at least 6 independently programmable force-off points, 1 for each non-coordinated phase. Two splits per background cycle shall be provided.

Timing Requirements. The time controls for programming the background cycle, offsets, force-off points and permissive periods shall be color or function coded. Timing of all functions shall be digital, with an accuracy of ± 100 milliseconds from the programmed value.

The ranges and maximum increments of adjustment for the various timing functions shall be in accordance with the following:

| Function | Minimum Timing Range | Maximum Increment of Adjustment |
|---|----------------------|---------------------------------|
| Background Cycle | 30 to 255 sec. | 1 second |
| Offset | 0 to 255 sec. | 1 second |
| Force-off Points and Permissive Periods | 0 to 99% of cycle | 1% of cycle |

The clock circuit of time based coordination units may use either the 60 Hz. A.C. power source or a crystal oscillator as the timing reference. If a crystal oscillator is used as the timing reference, the frequency tolerance of the clock circuit shall be $\pm 0.005\%$. The clock circuit of the time based coordination unit shall provide for a setting to the nearest second.

The time based coordination unit shall be provided with a programmable feature which automatically changes from standard time to daylight savings time and vice versa.

Battery Power. Time based coordination units shall be provided with a battery to power the clock circuit and memory for a minimum of 100 hours when the 120 Volt A.C. power source is disconnected.

Manual Override. Time based coordination units shall be designed so that the programmed time of day function can be manually overridden to select a different function, i.e., cycle, offset, splits, etc.

Indicator Requirements. Time based coordination units shall provide the following minimum indications:

1. Time of day(hours, minutes and seconds)
2. Day of week or calendar date
3. Outputs controlled by day program
4. Cycle count - indicates time in background cycle
5. Day program in effect
6. Week program in effect
7. Battery status

Construction. Time based coordination units shall be a built-in component to the controller.

Data Transfer. Time based coordination units shall provide transferring all programmed data from unit to unit by using a data transfer cable. A cable shall be supplied with each unit.

TRAFFIC SIGNAL SUPPORTS

730.32-Cantilever Signal Supports. These specifications apply to the manufacture of steel poles and mast arms for the support of traffic signals. The height of poles, shaft dimensions and wall thickness shall meet the design requirements and mounting height of traffic signals as set forth in these Specifications and in the Plans. Bracket arm lengths are indicated in the Plans.

The poles shall consist of a straight or uniformly tapered shaft, cylindrical or octagonal in cross section, having a base welded to the lower end and complete with anchor bolts. All castings shall be clean and smooth with all details well defined and true to pattern. Steel castings shall conform to ASTM A 27, Grade 65-35. Gray iron castings shall conform to ASTM A 126, Class A.

All mast arms shall be compatible with the poles in material, strength, shape, and size.

Anchor Base - An anchor base of 1-piece cast steel or steel plate of adequate strength, shape and size shall be secured to the lower end of the shaft. The base shall telescope the shaft and be welded at the top and bottom faces with continuous fillet welds so that the welded connection shall develop the full strength of the adjacent shaft section to resist bending action. Each base shall be provided with a minimum of 4 holes to receive the anchor bolts. Cast steel bases shall be provided with removable cast iron covers for anchor bolts and tapped holes for attaching covers with hex head cap screws.

A welded frame handhole, 5 x 8 in.(125 x 200 mm) minimum and located 1 ft.(300 mm) above the base, shall be provided. A ½ in.(13 mm)-13 UNC grounding nut shall be welded to the inside of pole at a point readily accessible for wiring.

Shaft - The shaft shall be fabricated from the best, hot rolled basic open hearth steel, and shall have only one longitudinal electrically welded joint and may have electrically welded intermediate transverse full penetration circumferential joints, at intervals of not less than 10 ft.(3 m). The shaft shall be longitudinally cold-rolled to flatten the weld and increase the physical characteristics so that the metal will have a minimum yield strength of 48,000 psi(331 Mpa). Where transverse full penetration circumferential welds are used, the fabricator of the shaft shall furnish to the Engineer certification: (1) that all such welds have been radiographed and ultrasonically tested by an independent testing laboratory using a qualified Nondestructive Testing(NDT) technician and (2) that the NDT equipment has been calibrated annually.

The shaft shall be fitted with a removable pole cap, a J-hook wire support welded inside near the top and a flange plate assembly to match that welded to the butt end of the mast arm.

Mast Arms - Mast arms shall be fabricated and certified in the same manner as the upright shafts and shall have the same physical characteristics.

The mast arms shall meet the design requirements necessary to support rigidly mounted traffic signals as designated in the Plans. All arms shall include a removable cap at the tip, grommets wire outlets and signal hanger assemblies of the type and number shown on the Plans, and a flange plate welded to the butt end to provide a rigid connection to the mast. The assembly shall be constructed so that all wiring can be concealed internally.

Mast arms shall be connected to the upright pole at a height necessary to provide a minimum clearance of 16 ft. 6 in.(5 m) and a maximum clearance of 19 ft. 0 in.(5.8 m) under the traffic signal heads. Separate signal heads shall be installed to provide the same clearance.

Finish - Steel poles, mast arms, and hardware, shall be galvanized in accordance with ASTM A 123.

All steel and cast iron components, hardware and threaded fasteners, except anchor bolts, shall be galvanized after fabrication in accordance with ASTM A 123, or A 153 or A 385, as applicable.

730.33-Steel Strain Poles. Steel strain poles shall consist of a uniformly tapered or equivalent upright shaft fitted with a removable pole top, J-hook wire support and 45 deg. wire inlet near the top, a span wire clamp, a 5 x 8 in. (125 x 200 mm) handhole with reinforced frame and cover, bent anchor bolts and any other accessories to make a complete installation. The pole and all of its component parts shall be designed to support tethered traffic signals of the type and number indicated on the Plans, suspended from a span wire assembly. The poles shall be fabricated and certified in the same manner as the upright shafts in **Subsection 730.32**.

The shaft length shall be determined by the Contractor as required to meet field conditions and vertical clearances of signal heads over the roadway. The signal head clearance shall be a minimum of 16 ft.-6 in.(5 m) and a maximum of 19 ft.(5.8 m). The span wire shall be fastened no closer than 1 ft.-6 in.(450 mm) from the top of the pole.

Unless otherwise specified, all strain pole traffic signal supports shall be provided with a one piece anchor type base. The base will be fabricated from drop forged or cast steel of sufficient cross section to fully develop the ultimate strength of the poles. The base shall be fastened to the pole by means of a welded connection and shall develop full strength of the pole. The base shall be provided with a minimum of 4 holes of sufficient size to accommodate the proper size anchor bolts that are capable of resisting at yield strength stress, the bending moment of the shaft at its yield strength stress. Removable cast iron covers for the anchor bolts shall be provided.

The shaft shall be fabricated from material providing a minimum yield strength of 48,000 ps (331 MPa) after fabrication.

Finish - Steel poles and hardware, shall be galvanized in accordance with ASTM A 123.

All steel and cast iron components, hardware and threaded fasteners, except anchor bolts, shall be galvanized after fabrication in accordance with ASTM A 123, or A 153 or A 385, as applicable.

730.34-Pedestal Support Signal Poles. The pedestal poles shall consist of one upright pole with suitable base and any other accessories or hardware as required to make a complete installation.

All poles shall be made of 1 continuous piece from top of base connection for the entire height of the pole. The cross section shall be either cylindrical or octagonal and may or may not be uniformly tapered from butt to tip.

The cross section at the tip shall have a 4 ½ in.(114 mm) outside diameter.

Type "A" Pedestal(Aluminum) - Pedestals shall be of uniform octagonal or cylindrical cross section of the tubular tapered type fabricated of one full length sheet.

Bases shall be octagonal or square in shape, of the ornamental type fabricated of cast material. A handhole shall be provided in each base.

Caps shall be of the nipple or tenon type mounting fabricated of cast material.

Bases shall be furnished with four steel anchor bolts of sufficient size and length to securely anchor the base to the concrete footing. The shaft shall be welded to the cast metal base. Refer to the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals(current edition).

Type A pedestal shaft shall be fabricated from aluminum tubing 6063-T4 heat treated to T-6 temper after fabrication, and meeting ASTM B 221.

Type A anchor base shall be made of sand-cast aluminum alloy 356-T6 meeting ASTM B 26 - SF 70A-T5 specifications.

Type "B" Pedestal(Steel) - Pedestal shall be fabricated from a 4-1/2 in.(114 mm)(outside diameter) seamless steel pipe.

Bases shall be octagonal in shape of the ornamental type fabricated of cast or malleable iron and shall have minimum height of 12 in.(300 mm). The top opening of the base shall be threaded to receive the shaft. A handhole shall be provided in each base.

Bases shall be furnished with four steel anchor bolts of sufficient length to securely anchor the base to the concrete footing.

730.35-Wooden Pole Signal Supports. Wooden poles shall be of the class and length described in the Plans and shall meet the requirements of **Subsection 917.11** of the Standard Specifications. Poles shall be set to the depth shown in the Plans and fitted with all necessary hardware to make the installation complete.

The signal head clearance shall be 16 ft.-6 in.(5 m) minimum and 19 ft.(5.8 m) maximum. The span wire shall be fastened at least 2 ft.(600 mm) below the top of the pole.

Guying Components - Guy clamps shall be steel, 3-bolt type, 6 in.(150 mm) length, and of the proper strand size to fit the wire used. The clamp bolts shall have upset shoulders fitting into the clamp plate. Substitution of the cable grip is subject to approval by the Engineer.

Guy wire shall be attached to the pole with a 5/8 in.(16 mm) diameter x 12 in.(300 mm) length single strand angle-type eye bolt with 2 x 2 in.(50 mm) square cut washers, lock washer and square nut.

In lieu of the eye bolt above, an angle single strand eye of drop forged steel may be used, fastened on threaded end of span wire eye bolt.

Sidewalk guy fittings shall consist of 2 in.(50 mm) I.D. standard galvanized steel pipe of required length with malleable iron pole plate and guy clamp. Pole plate to be fastened to the pole with a 3/8 in.(10 mm) thru bolt and 1/2 in.(13 mm) lag screws.

All guying components and hardware shall be galvanized in accordance with ASTM A 123 or A 153.

Anchors for guys shall be of the pressed steel 4-way expanding fluke type or of the steel or malleable iron sliding plate type. The minimum unexpanded diameter shall be 8 in.(200 mm), and the minimum expanded area shall be 110 s.f.(7 cm²). Anchors shall be coated with a black asphaltic paint.

Guy anchor rods shall be drop-forged steel, 3/4 in.(19 mm) diameter and 7 ft.(2.1 m) minimum length, threaded, of the single thimble eye type, with a square anchor bolt nut.

730.36-Pole Location. All signal support poles shall be installed at locations shown on the Plans or where directed by the Engineer.

COMPENSATION

730.37-Method of Measurement. Measurement for traffic signals will be on a per-item basis for each item to be furnished and installed, as specified herein and shown on the Plans.

With regard to items for signal head assemblies, each item to be furnished and/or installed shall be distinguished with a code number as follows:

1. The first digit is the number of faces per assembly.
2. The second digit will indicate the number of 12 in.(300 mm) lenses per assembly(including arrow lenses).
3. The third digit is the quantity of 8 in.(200 mm) lenses per assembly.
4. The letter "A" indicates an arrow lens and the digit following the "A" indicates the number of 12 in.(300 mm) arrow lenses per assembly.
5. The letter "H" or "V" indicates the arrangement of arrow signal lenses to be horizontal or vertical with respect to solid ball indications.

EXAMPLE:

1 5 0 A 2 H

Digits Indicate as Follows:

1 = 1 Face

5 = 5-12 in.(300 mm) Lenses

0 = 0-8 in. (200 mm) Lenses

A2 = 2-12 in.(300 mm) Arrow Lenses

H = Arrow Lenses placed horizontally with respect to circular indications.

Removal of Signal Equipment

Items of equipment or material designated or required for removal shall be measured on a per each intersection basis. Removal and salvage of all signal heads, poles, control equipment, cabinets, span wire, cable, etc., to be performed at an intersection shall be included as a unit cost per each intersection. This includes the cost of stockpiling salvable equipment for pick-up by the appropriate agency, as noted in the Plans.

Signal Head Assembly(includes pedestrian signal heads)

Signal heads of the type indicated in the Plans shall be measured by the individual assembly complete in place, per each. This item shall include the

signal heads, terminals, lamps, attachment hardware, cable connection, and testing.

Pull Box

Each pull box of the type required shall be measured as one complete unit, installed, per each. This item includes the pull box, excavation, backfilling, crushed stone base and other incidental items as called for in the Plans or Standard Drawings.

Electrical Service Connection

Electrical Service Connections shall be measured on a per each signal installation basis. This item includes the electrical service supplied to the weatherhead by the local utility, all necessary materials and labor for connection of the electrical service from the controller to the weatherhead, the wiring of the controller and detectors, and all incidentals necessary to render a complete and operable system.

Signal Cable

The length of signal cable of each size(number of conductors) installed shall be measured in linear feet(meter) to the nearest foot(meter) from point to point along the routing for each cable.

Horizontal measurements shall be made by center to center measurement from:

1. pole to pole
2. pole to signal head(when terminating in a signal head)
3. pull box to pull box
4. pull box to pole
5. pull box to pole-mounted or base-mounted controller

For cable inside mastarms, measurement shall be made from center of vertical support to signal head where cable terminates.

Vertical measurement shall be made by one of the following:

1. For cable inside poles or conduit risers, the distance from ground level to the point of attachment of the span wire.
2. For cable inside mastarm supports, the distance from ground level to the mastarm connection.
3. For cable to pole-mounted controller,
 - A. from ground level to bottom of controller.
 - B. from bottom of controller to point of attachment of span wire.
4. For cable to pole-mounted signal head or pushbutton,
 - A. from ground level to bottom of signal head or pushbutton

730

- B. from bottom of signal head or pushbutton to point of attachment of span wire.

No additional allowance will be made for slack length, length inside equipment or supports(except as noted), length for the required 360° drip loop, and similar instances where additional length of cable is required.

Span Wire

Span wire assembly, tether wire assembly, and messenger cable by type shall be measured in linear feet(meters) to the nearest foot(meter). The measurement will be made from center to center of poles. These items include attachment hardware, strain insulators, and other hardware shown in the Plans as part of the assembly. No additional allowance will be made for slack length and other instances where additional length of wire is required.

Steel Conduit Riser Assembly

Conduit riser assemblies shall be measured per each for each size conduit riser installed on the outside of a pole, as required in the Plans. This item includes conduit, weatherhead, conduit, fittings, nuts, washers, banding, clamps, grounding, and other items necessary for installation.

Conduit

Conduit shall be measured in linear feet(meters) to the nearest foot(meter) for each size and type of conduit installed. Underground conduit will be measured along the conduit by one of the following:

1. From the face of curb to the center of a pull box, pole or controller foundation
2. From center to center of pull boxes
3. From center to center of a pull box and a pole or controller foundation
4. From center to center of pole foundations or pole foundation and controller foundation.

One ft.(1 m) will be added to the above measurements for each entry to a pull box or pole foundation and each exit of a pull box or pole foundation. Three ft.(1 m) will be added to the measurement for each capped extra entry(conduit stub) or exit to a pull box or pole foundation installed, as directed in the Plans. Three ft.(1 m) will be added to the measurement for each connection between underground conduit and above ground riser. Three ft. (1 m) will be added to the measurement for each entry or exit to a foundation for a base-mounted controller.

This item includes trenching, backfilling, sealing, capping, fittings, bushings, banding, grounding, and other accessories and hardware required for installation of the conduit system.

Vehicle Loop Detector(Amplifier)

Vehicle detector loop amplifier shall be measured per each unit and include the cable and associated hardware necessary to electrically connect the amplifier to the controller and loop lead in. Two and 4 channel card rack type amplifiers shall be measured per each unit and include the cable, card rack(s), and associated hardware necessary to electrically connect the amplifiers to the controller and loop lead-ins.

Shielded Detector Cable

Two-conductor shielded detector cable installed between the controller cabinet and the loop detector wires shall be measured in linear feet(meters) to the nearest foot(meter). Horizontal measurements(overhead and underground) will be made by 1 of the following:

1. From center to center of pull boxes
2. From center to center of pull box and pole
3. From center to center of poles
4. From center to center of pull box or pole and controller foundation.

Vertical measurements will be made by 1 of the following:

1. From ground level to the point of attachment of span wire, inside pole or conduit riser.
2. From the bottom of controller cabinet to the point of attachment of span wire.
3. From ground level to the bottom of controller.

No additional allowance will be made for slack length, length inside equipment or supports(except as noted), splices, and similar instances where additional length of cable is required.

Saw Slot

Length of saw slot for installation of detection loop and lead wiring shall be measured in linear feet(meters) to the nearest foot(meter). Measurement for detection loops in the traffic lanes shall be made based on the loop size specified in the Plans, i.e., the nominal length plus the nominal width times 2. No additional allowance will be made for saw overruns to obtain full depth of saw slot or diagonal cuts to prevent sharp bends in the loop wire. Measurement of saw slot for detection loop leads shall be made from the conduit entry at the face of curb or edge of pavement and along the route of the lead-in to the detection loop.

This item includes backing rods, or polyethylene foam sealant, loop sealant, and any other incidentals necessary to render a complete and operable system.

Loop Wire

730

Length of loop wire for installation of detection loops and lead-ins shall be measured in linear feet(meters) to the nearest foot(meter). Measurement shall be made from the pull box or pole to the detection loop, around the loop the required number of turns and back to the pull box, pole, or point of splice. No additional allowance will be made for slack length, length inside equipment or supports, splices, and similar instances where additional length of wire is required.

This item includes electrical connections, testing, and any other incidentals necessary to render a complete and operable system.

Controller

Controllers shall be measured as one complete unit, installed, per each. This item includes all auxiliary equipment indicated in the Plans to provide signalization control as specified in the Plans, and all hardware, including the cabinet(and cabinet foundation, if base-mounted), necessary for installation.

Wood Pole

Wood Poles, of the type and size indicated in the Plans, shall be measured per each, installed.

Guying Device

Guying Devices, of the type indicated in the Plans, shall be measured per each, installed. This item includes the guy wire, anchor, clamps, and all other components indicated in the Plans necessary for installation.

Steel Strain Pole

Steel Strain Poles of the type and size shown in the Plans, shall be measured per each, installed. This item includes the pole, foundation, anchor bolts, grounding, and all other hardware indicated in the Plans necessary for a complete installation.

Cantilever Signal Support

Cantilever Signal Supports, of the type and size shown in the Plans, shall be measured per each, installed. This item includes the vertical pole shaft, mastarm, foundation, anchor bolts, grounding, and all other hardware indicated in the Plans necessary for a complete installation.

Service Cable

Two conductor power service cable of the type and size indicated in the Plans shall be measured in linear feet(meters) to the nearest foot(meter), installed. Horizontal runs will be measured center to center of poles. Vertical runs will be measured from the ground to the weatherhead inside a

pole or conduit riser, or from the ground to the bottom of the controller, or from the bottom of the controller to the weatherhead. This item includes all necessary attachment hardware. No additional allowance will be made for slack length or other instances where additional length of cable is required.

Pedestrian Pushbutton with Sign

Pedestrian Pushbutton with Sign shall be measured as 1 complete unit, in place, per each. This item includes the pushbutton, sign, mounting hardware, wiring of pushbutton, testing, and all other incidentals necessary for a complete installation.

Pedestrian Signal Display with Pushbutton and Sign

Pedestrian Signal Display with Pushbutton and Sign shall be measured as 1 complete unit, in place, per each. This item includes the signal heads, terminals, lamps, cable connections, pushbutton, sign, all attachment hardware, testing, and other incidentals necessary for a complete installation.

730.38-Basis of Payment. The unit price to be paid shall include the cost of furnishing and installing, complete in place, each of the various types of equipment required by the Summary of Quantities which are a part of the Plans. Total payment will be payment in full for all materials, labor, equipment and incidentals necessary to produce a completely operative and finished installation of a traffic signal or traffic signal system as shown on the Plans and as herein specified, including restoration of pavements, sidewalks and appurtenances damaged or destroyed during construction and tests. Full compensation for all additional materials and labor not specifically shown or called for, which is necessary to complete the traffic signal installation or traffic signal system described, shall be considered and included in the total payment for the system and no additional allowance will be made therefor.

740

SECTION 740-GEOTEXTILES

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|--|------------|
| 740.01-Description | 689 |
| 740.02-Materials..... | 689 |
| 740.03-General | 689 |
| 740.04-Method of Measurement..... | 689 |
| 740.05-Basis of Payment..... | 689 |

SECTION 740-GEOTEXTILES

740.01-Description. This work shall consist of the placement of geotextiles in accordance with these Specifications, at the locations and in reasonably close conformity with the lines, grades and dimensions shown on the Plans, or established by the Engineer.

MATERIALS

740.02-Materials. Materials used in this construction shall meet the requirements of **Subsection 918.27** for the Type Geotextile called for in the plans.

The contractor shall furnish a certified laboratory test report from an approved testing laboratory with each shipment of materials. Laboratory test reports shall include the actual numerical test data obtained. All rolls shall be clearly labeled as being part of the same production run from which the test date was derived. Fabric shall be protected to prevent damage during transportation, storage, and installation. Geotextile rolls shall be covered during storage to protect against UV degradation and shall be stored with rolls elevated up off of the ground. Fabric that is torn, punctured, or otherwise damaged shall not be installed.

CONSTRUCTION REQUIREMENTS

740.03-General. Geotextile fabric shall be placed as specified on the Plans for the specific application. The surface on which the geotextile fabric is to be placed shall be compacted, as directed by the Engineer, and prepared as smooth as possible and free from debris, obstructions and depressions which could result in gaps, tears, or punctures in the fabric during cover operations. The geotextile shall be installed in such a manner that placement of cover material will not excessively stretch nor tear the geotextile. After fabric is placed, the initial lift of cover material shall be installed within 5 calendar days. Under no circumstances shall any equipment operate directly on the geotextile fabric. Cover material shall be placed such that at least the minimum initial lift thickness, as specified by the Engineer, is between the geotextile and equipment tires or tracks at all times. Turning of equipment/vehicles shall not be allowed on the first lift above the geotextile.

COMPENSATION

740.04-Method of Measurement. Geotextiles of the type specified shall be measured by the s.y. (m²), complete in place. No measurement for payment will be made for overlaps, splices, sewing joints, etc.

740.05-Basis of Payment . The accepted quantities of Geotextiles of the type specified, measured as provided for above, will be paid for at the contract unit price per s.y.(m²) complete in place, which price shall be full compensation for labor, equipment, materials, tools and all incidentals necessary to complete the work. Fabric that is damaged during or after

740

placement shall be replaced or repaired, as directed by the Engineer, at the expense of the Contractor.

690