# TRAFFIC CONTROL

# 400.1 GENERAL

This section contains specifications which are relative to the protection of the public with respect to traffic control, such as: concrete wall and metal barrier, barrier posts, fencing, traffic signal equipment, street lighting equipment, signing and markings

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#### CONCRETE WALL AND METAL BARRIERS

### 401.1 GENERAL

For the protection of the public, either in a vehicle or as a pedestrian, there is a necessity for the construction of approved concrete wall and metal barriers along hazardous locations. This section specifies the requirements for the installation of these barriers.

# 401.2 REFERENCES

New Mexico State Department of Transportation Standard Specifications for Highway and Bridge Construction.

# 401.3 MATERIALS AND CONSTRUCTION

401.3.1 The materials and construction of concrete wall and metal barriers shall conform to Section 606 of the NMDOT Specifications for Highway and Bridge Construction and to the NMDOT Standard Detail Drawings, some of which have been included in these specifications.

401.3.2 Location of concrete wall barriers and specific anchorage details will be shown on the construction plans.

#### 401.4 MEASUREMENT AND PAYMENT

401.4.1 Measurement for metal barriers and appurtenances shall be by the linear foot of barrier (including rail, posts and installation) or by the unit, such as end section or individual posts. Payment shall include all materials and labor necessary for the installation, as specified in the Bid Proposal.

401.4.2 Measurement for concrete wall barriers shall be by the linear foot along center line of barrier (including jointing and necessary anchoring). Payment shall include all materials and labor associated with the installation, as specified in the Bid Proposal.

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#### 410.1 GENERAL

This work shall consist of the construction of fences and gates in substantial compliance with the specifications, lines, and grades shown on the plans or established by the ENGINEER.

#### 410.2 REFERENCES

#### 410.2.1 ASTM:

А	1	A 153
Α	36	A 392
А	116	A 499
А	120	A 525
А	121	A 569
Α	123	B 209

#### 410.2.2 AASHTO:

Μ	111
Μ	133
Μ	181

#### 410.3 MATERIALS

#### 410.3.1 GENERAL:

410.3.1.1 The CONTRACTOR shall submit the required number and type of test certificates to the ENGINEER certifying that the fencing materials conform with the requirements herein provided. When the locations of manufacturing plants allow, the plants will be inspected periodically for compliance with specified manufacturing methods, and material samples will be obtained for laboratory testing for compliance with materials quality requirements. This can be the basis for acceptance of manufacturing lots as to quality. All materials will be subject to inspection for acceptance as to condition at the latest practicable time the ENGINEER has the opportunity to check for compliance prior to or during incorporation of materials in the work.

410.3.1.2 All materials shall be new and without flaws or defects of any type.

#### 410.3.2 WIRE FENCE

410.3.2.1 WIRE:

410.3.2.1.1 Barbed wire shall conform to ASTM A 121, Class 3, coating and shall consist of two

strands of 12-1/2 gauge wire with 4-point 14-gauge round barbs spaced approximately 5 inches apart. In lieu of Class 3 galvanizing, the wire may be coated with aluminum alloy at the rate of not less than 0.30 ounce per square foot of wire surface and the barbs at the rate of not less than 0.25 ounce per square foot of wire surface.

410.3.2.1.2 Woven wire shall conform to ASTM A 116, design number 832-6-11 (shown in Appendix Table) or as shown on the plans, Class 3 coating or coated with aluminum alloy at the rate of not less than 0.25 ounce per square foot of wire surface. The height shall be 32 inches.

410.3.2.1.3 Staples for fastening fence wire to wood post

s shall be galvanized 9 gauge, 1-1/2 inches long.

410.3.2.1.4 Brace wire shall be 9 gauge, galvanized and shall be used in the construction of braces and intermediate braces when wood posts are used.

410.3.2.1.5 Tie wires for fastening barbed wire or woven wire to steel posts shall be not less than 12-1/2 gauge and galvanized. Eleven gauge or heavier wire fasteners or metal clamps may be used in lieu of tie wires when approved by the ENGINEER. Aluminum tie wires will not be accepted.

410.3.2.1.6 Stays for barbed wire fences shall be not less than 9-1/2 gauge galvanized wire conforming with ASTM A 116 and of length and spacing shown on the plans.

410.3.2.2 POSTS: Corner, brace, intermediate brace, gate, and line posts shall be metal or wood and of the type, size, and length shown on the plans and as herein provided.

410.3.2.2.1 Metal posts and braces shall be fabricated from rail, billet, or commercial grade steel conforming with any of the following ASTM Designations: A 1, A 499, and ASTM A 120 (for pipe posts) and shall be galvanized or painted as required. Galvanizing shall conform with ASTM A 123 and painting shall conform with the requirements shown on the plans. Corner, gate, and intermediate brace posts shall be tubular, section, or angles of the type and dimensions shown on the plans. Corner, gate and

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intermediate brace posts and braces shall be set in concrete as shown on the plans. Line posts shall have a minimum weight of 1.33 pounds per foot exclusive of anchor plates. A minus tolerance of not to exceed 5 percent of the minimum weight of each post will be permitted. A plus tolerance of 2 inches and a minus tolerance of 1 inch in the length of each post will be permitted. Line posts may be I-beam, T-beam, U-beam, Y-bar, or H-column section. Line posts shall be provided with corrugations, lugs, ribs, or notches spaced approximately 1 inch on centers to engage the required fence wire in designated spaces. Posts with punched tabs intended to be crimped around the wire will not be accepted. Anchor plates shall have an area of not less than 19 square inches. shall weigh not less than 0.64 pound each, and shall be securely welded, bradded, or riveted to each line post.

410.3.2.2.2 Wood corner, brace, intermediate brace, gate and line posts shall be southern yellow pine, lodge pole pine, or ponderosa pine and of the length and dimensions shown on the plans. Posts shall be cut from live trees and shall be straight and free from decay and other defects. Line posts may have a single crook in one direction but shall not vary more than 1-1/2 inches from a straight line connecting both ends of the post. All bark shall be peeled and the posts trimmed and smooth of all knots and projections, and both ends of the posts shall be sawed off perpendicular to the centerline.

410.3.2.2.3 Wood corner, brace, intermediate brace, and gate posts shall be of the length shown on the plans. The average nominal diameter of the top of each post shall be not less than 6 inches. The circumference of corner, brace, intermediate brace, and gate posts shall be measured 6 inches below the top of post and shall not be less than 19 inches. The average nominal diameter of the top of each line post shall be not less than 3 inches. The circumference of line posts shall be measured 6 inches below the top of the post and shall be not less than 9-1/2 inches.

410.3.2.2.4 Wood posts shall be pressure treated with standard creosote oil or petroleum-pentachlorophenol consisting of not more than 95 parts by weight of petroleum and not less than 5 parts by weight of pentachlorophenol. The empty cell process shall be used. The amount of creosote oil retained shall be not less than 6 pounds per cubic foot of wood, and the amount of pentachlorophenol retained shall be not less than 0.3 pound of dry salt per cubic foot of wood. Wood preservatives shall conform with AASHTO M 133.

410.3.2.2.5 Braces for wood posts shall be coast region Douglas fir, New Mexico red spruce or fir and shall conform with dimensions shown on the plans.

410.3.2.3 GATES: Gates shall be only tubular steel frame or tubular steel frame with filters of wire fabric, metal panel, chain link, or barbed wire, conforming with the dimensions and details shown on the panels. Materials and galvanizing shall be in conformity with the requirements of ASTM A 116 Class 3, A 120, A 392, A 525, and A 123 where applicable. Aluminum panel gates shall conform to ASTM B 209, and shall be installed if specifically required by the construction plans. Aluminum gates will not be arbitrarily substituted for tubular steel frame gates.

410.3.2.4 FITTINGS: All fittings, hardware, and appurtenances for fences and gates shall be commercial quality steel, malleable iron or wrought iron and shall be galvanized in accordance with the requirements of ASTM A 153.

# 410.3.3 CHAIN LINK FENCE:

410.3.3.1 Post shall be galvanized steel, tubular or H-column, conforming with the lengths, dimensions and weights shown on the plans. Tubular posts, braces, and top rails shall conform with the requirements of ASTM A 120 for galvanized standard weight pipe, except that the pipe shall not be threaded nor subjected to hydrostatic test. H-column posts shall conform to ASTM A 36. The galvanizing shall conform to the requirements of AASHTO M 111 (ASTM A 123).

410.3.3.2 Post tops, stretcher bars, hardware and other required fittings shall be of commercial quality steel or malleable iron, and the galvanizing shall conform with the requirements of ASTM A 153.

410.3.3.3 Tie wires for fastening chain link fence to posts and rails shall be 9 gauge and galvanized. Galvanized steel or noncorrosive metal bands or

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fasteners may be used in lieu of tie wires when approved by the ENGINEER. Aluminum tie wires will not be accepted.

410.3.3.4 Compression braces shall conform with the same requirements as top rails. Tension truss rods shall be not less than 3/8 inch round galvanized rods with drop-forged turnbuckles or other approved tension device.

410.3.3.5 Chain link fabric shall conform to the requirements of AASHTO M 181. Unless otherwise provided, the wire shall be No. 9 gauge galvanized wire and the fabric shall be 2 inch mesh.

410.3.3.6 Gates may be double drive, single drive, or single walk and shall conform with the dimensions and details shown on the plans. Gate frames shall be fabricated from galvanized steel pipe conforming with ASTM A 120 and A 123. Chain fabric filler shall conform to the requirements herein provided for chain link fabric.

410.3.3.7 Corner posts shall be 3 inches O.D. with a minimum weight of 5.8 lb. per ft. Line posts shall be 2-1/2 inches O.D. with a minimum weight of 3.66 lb. per ft. Top rail and braces shall be 1-5/8 inches O.D. with a minimum weight of 2.27 lb. per ft.

410.3.3.8 At the option of the CONTRACTOR, posts, rails, braces, and gate framing members may be pipe manufactured from steel conforming to ASTM A 569, cold rolled, and coated with a minimum or 0.9 ounces of zinc per square foot, a minimum of 15 micrograms of zinc chromate per square inch and a minimum of 3 mils cross-linked polyurethane acrylic exterior coating, in lieu of fencing members conforming to the requirements specified above and in Subparagraph F below, except that the outside diameter of the pipe shall be as specified above, and with thickness and weight as per Table 410.3.3.8.

410.3.3.9 When outriggers with barbed-wire are installed the lowest strand shall not be less than 8 feet high measured from ground level. The same clearance distance will be required for coiled security wire.

#### 410.4 CONSTRUCTION REQUIREMENTS

410.4.1 CONSTRUCTION METHODS: The CONTRACTOR shall perform such clearing and grubbing as may be necessary to construct the fence to the required grade and alignment. At locations where breaks in a run of fencing are required or at intersections with existing fences, appropriate adjustment in post spacing shall be made to conform to the requirements for the type of closure indicated. When the plans require that posts, braces, or anchors be embedded in concrete, the CONTRACTOR shall install temporary guys or braces as may be required to hold the posts in proper position until such time as the concrete has set sufficiently to hold the posts. Unless otherwise permitted by the ENGINEER, no materials shall be installed on posts or strain placed on guys and bracing set in concrete until 7 days have elapsed from the time of placing of the concrete. The tops of all posts shall be set to the required depth and alignment. Cutting of the tops of posts shall be allowed only with the approval of the ENGINEER and under the conditions specified by him. Wire or fencing of the size and type required shall be firmly attached to the posts and braced in the manner indicated. All wire shall be stretched taut and be installed to the required elevations. At each location where an electric transmission, distribution, or secondary line crosses any of the types of fences covered by these specifications, the CONTRACTOR shall furnish and install a ground conforming to the drawings shown on the plans.

# 410.4.2 WIRE FENCE:

410.4.2.1 Wire fences shall be constructed in conformity with the details and at locations shown on the plans or staked by the ENGINEER. All posts shall be set plumb and to the depth and spacing shown on the plans. Excavations for footings and anchors shall be to dimensions shown on plans or established by the ENGINEER. Metal line posts may be driven. Post hole backfill shall be placed in thin layers and each layer solidly compacted. Posts set in rock shall be placed as per construction plans.

410.4.2.2 Fence wire shall be stretched by mechanical stretcher or other device designated for such use. Stretching by motor vehicle will not be permitted. The length between pull posts shall not exceed 995 feet for barbed wire and 660 feet for woven wire.

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410.4.2.3 Intermediate braces shall be placed at intervals not to exceed 1000 feet and shall be spaced evenly between corner and gate posts or cattle guards.

410.4.2.4 A corner post and brace shall be placed at the intersection of cross fences with the right-of-way fence. Cross fence wires shall be stretched and firmly attached to the corner posts. 410.4.2.5 Right-of-way fences shall be attached to roadway structures when shown on the plans.

410.4.2.6 Fence materials of the same manufacture, type or process, conforming with the details shown on the plans shall be used throughout the Work unless otherwise authorized in writing by the ENGINEER.

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# TABLE 410.3.3.8

# FENCE PIPING DIMENSIONS AND WEIGHTS

.Fence	Nominal	Decimal	Minimum	Minimum
Industry	Pipe Size	Equivalent	Wall	Weight
O.D. (in)	I.D. (in)	O.D. (in)	<u>Thickness (in)</u>	<u>lbs per foot</u>
1-5/8	1-1/4	1.660	0.111	1.836
2-1/2	2	2.375	0.130	3.117
3	2-1/2	2.875	0.160	4.640

### FENCES

#### 410.4.3 CHAIN LINK FENCE:

410.4.3.1 Chain link fences shall be constructed in conformity with the details and at locations shown on the plans or staked by the ENGINEER. Posts shall be spaced at not more than 10 foot intervals. The intervals shall be measured from center to center of post. All posts shall be set in concrete footings conforming with the dimensions and details shown on the plans. Posts set in rock shall be approved by the ENGINEER. Chain link fabric shall not be attached to posts until the concrete footings have completely set. Pull posts shall be line posts braced to adjacent line posts as shown on the plans. Pull posts shall be spaced at intervals not to exceed 500 feet. End posts shall be not less than 2.875 inches in outside diameter and braced in the same manner as corner posts. Braced tension rods or cables, hardware, and appurtenances shall be installed as shown on the plans.

410.4.3.2 Chain link fabric shall be stretched by mechanical stretcher or other device designed for such use. Stretching by motor vehicle will not be permitted.

# 410.5 REMOVING AND REBUILDING FENCE

As shown on the construction plans or directed by the ENGINEER existing fences may require removal and re-erected. Such fences shall be reconstructed to the same condition as the original fence or better. The materials in existing fences to be removed and rebuilt shall be salvaged and incorporated in the rebuilt fences. Fence materials damaged beyond reuse during removal or rehandling shall be replaced by the CONTRACTOR at his expense. Posts shall be firmly reset to the line shown on the plans. The spacing of the posts and the material to be strung and secured to the posts shall be the same as the original fence. New tie material or staples shall be used to fasten the fence material to the posts and shall be furnished by the CONTRACTOR at his expense.

#### 410.6 MEASUREMENT AND PAYMENT

410.6.1 For new fences the measurement and payment will be by one of the following methods:

410.6.1.1 By the linear foot. Measurement will be along the top of the fence from outside to outside of end posts for each continuous run of fence. The accepted quantities of fence will be paid for at the Bid Proposal's unit price per linear foot complete in place for the specified type of fence.

410.6.1.2 By the square foot. Measurement will be the horizontal distance of the fence from outside to outside of end posts for each continuous run multiplied by the vertical measurement of the material; the product area shall be designated in square feet. Payment will be made on the Bid Proposal's unit price per square foot complete in place for the specified type of fence.

410.6.1.3 Regardless of which method is used, payment shall include the cutting, removal, and replacement of any concrete or asphalt surfacing associated with the fence installation.

410.6.2 Removal and rebuilding of a fence shall be measured by the linear foot of fence removed and rebuilt and payment will be made on the unit price per linear foot for the type of fence as specified in the Bid Proposal.

410.6.3 Removal and disposal of a fence shall be measured by the linear foot of fence removed and disposed of by the CONTRACTOR. Payment will be made on the unit price per linear foot for the type of fence as indicated in the Bid Proposal.

410.6.4 Measurement and payment for gates will be the unit price per each for the type of fencing material specified in the Bid Proposal.

# GENERAL CLAUSES FOR TRAFFIC SIGNAL AND STREET LIGHTING SYSTEMS

420.1 GENERAL: The work performed under this specification shall consist of furnishing and installing complete and functioning traffic signal and street lighting systems in compliance with the specifications, details shown on the plans, and Standard Drawings at locations shown on the plans or as established by the ENGINEER.

420.2 DEFINITIONS: The following definitions pertain only to traffic signal and street lighting systems:

420.2.1 Beacon - A flashing signal indication used for hazard identification or intersection control, normally post or span wire mounted.

420.2.2 Breakaway - The ability of a standard to yield at a predetermined impact force.

420.2.3 Controller Cabinet - An outdoor housing which contains a traffic actuated controller and all other associated equipment to perform the necessary switching of illuminated signal indications.

420.2.4 Detector - A device by which vehicles or pedestrians are enabled to register their presence with a controller.

420.2.5 Foundation - A concrete structure, embedded in the ground, which supports and anchors a standard, controller cabinet, or splice cabinet.

420.2.6 Installation - The work completed, in place, and in proper operation.

420.2.7 Lighting Control Cabinet - An outdoor housing which contains contactors, photo electric controllers, switches, and other auxiliary equipment to control lighting systems.

420.2.8 Luminaire - A lighting device designed to illuminate the surface of a specific area from a mounting on a standard; includes the housing, optical control, lamps, and any necessary ballasts.

420.2.9 Overlap - The allocation of right of way to a special traffic movement during two or more phases.

420.2.10 Phase - The ability of a controller to allocate time (right of way) to any traffic movement(s) which may occur during one or more intervals (period of unchanged indications) of a complete cycle.

420.2.11 Service - The connection of a signal or lighting system to an electrical utility distribution system, mounted on a pole or enclosed in a cabinet, and including the necessary protection device, meter enclosure, and any required switching devices.

420.2.12 Signal Assembly - A housing containing the required 420-1

illuminated traffic signal indications (vehicular and pedestrian) mounted on a standard.

420.2.13 Splice Cabinet - An outdoor housing which contains terminal blocks for connecting communication cables.

420.2.14 Standard - A pole type structure which supports and positions signal and lighting devices including arms, mounting hardware, and breakaway devices as required.

420.2.15 System Master - An electronic device normally installed in a controller cabinet which is capable of supervising an interconnected network of local controllers, providing coordinated traffic movement. System masters in turn may be controlled by a computerized traffic control system.

420.2.16 Traffic Actuated Controller - An electronic timing device which controls the timing and sequence of traffic phases in accordance with the varying demands of traffic registered by detectors.

420.2.17 Traffic Control System - A complete system of signalized intersections with a remote computer including all communications devices, peripheral equipment and sampling detectors.

420.2.18 ENGINEER- The OWNER, designer, or ENGINEER who is responsible for acceptance and maintenance of the signal and lighting system. Contact the ENGINEER in case of traffic operations emergencies.

420.2.19 Traffic Signal - The complete installation of a traffic control system at a roadway intersection, including the illuminated signal indications, supports, electrical controls, and distribution system.

- 420.3 REFERENCES
- 420.3.1 Aluminum Association Standards, Latest Edition
- 420.3.2 American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications, Latest Edition
- 420.3.3 American National Standards Institute (ANSI) Standards, Latest Edition
- 420.3.4 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition
- 420.3.5 Federal Highway Administration (FHWA) Standards, Latest Edition
- 420.3.6 Government Services Administration (GSA) Standards, Latest Edition
- 420.3.7 Institute of Transportation Engineers (ITE)

# GENERAL CLAUSES FOR TRAFFIC SIGNAL AND STREET LIGHTING SYSTEMS

Publications, Latest Edition

- 420.3.8 International Municipal Signal Association (IMSA) Standards, Latest Edition
- 420.3.9 Manual on Uniform Traffic Control Devices (MUTCD), Latest Edition
- 420.3.10 National Electrical Code (NEC), Latest Edition
- 420.3.11 National Electrical Manufacturers Association (NEMA) Standards, Latest Edition
- 420.3.12 Rural Electrification Administration (REA) Standards, Latest Edition
- 420.3.13 This Publication, Latest Edition
- 420.3.14 Underwriters Laboratories Standards, Latest Edition
- 420.3.15 United States Standards, Latest Edition
- 420.4 MATERIALS.
- 420.4.1 SIGNAL AND LIGHTING MATERIALS:

420.4.1.1 GENERAL

420.4.1.1.1 Materials shall be new unless provided otherwise on the plans or in the specifications. In addition to the requirements shown on the plans or in the specifications, electrical materials shall conform to NEMA standards and NEC requirements and to any applicable state or local ordinances or requirements. In the event revisions to NEMA and/or NEC requirements create a conflict with material requirements in these specifications, the latest NEMA and/or NEC requirements shall apply.

420.4.1.1.2 Signal and lighting systems shall be complete with all necessary accessories for proper operation. Disconnect devices, protective devices, and other devices and materials shall be thoroughly coordinated to secure the required results with the greatest assurance of protection to life and property consistent with these specifications and the NEC. The plans indicate the extent and general arrangement of signal and lighting systems. Incidental parts not shown on the plans or included in the specifications which are necessary to complete new systems or modify existing systems shall be furnished and installed as though such parts are shown on the plans or provided for in the specifications.

420.4.1.2 MATERIAL APPROVALS: Within fifteen (15) calendar days after notice to proceed is issued, the CONTRACTOR shall submit for approval to the ENGINEER a list of signal and lighting materials he proposes to furnish and the source of supply for these materials. Materials which are identified on the plans or in the specifications by performance characteristics shall be included on this list. The list shall include the name of the manufacturer, size, and catalog number of each item and shall be supplemented by other performance data when required on the plans and/or specifications. Submittals for all standards (poles) shall include complete shop drawings and material certifications. The CONTRACTOR shall submit sample articles of the material he proposes to use when requested by the ENGINEER or called for on the plans or as specified in Section 1502 - Submittals.

420.4.1.3 PREQUALIFICATION: All traffic actuated controllers, controller cabinets, signal monitors, vehicle detectors, load switches, signal standards, lighting standards, and luminaires to be provided by the CONTRACTOR shall be pretested and accepted by the ENGINEER. The list of pretested and acceptable signal items is available from the ENGINEER. Each acceptable item will be listed as to manufacturer and model (or identification) number. Sample items may be submitted (or resubmitted) at any time before or after the opening of bids by the manufacturer or its representative to the ENGINEER. However, the CONTRACTOR shall take full responsibility to assure him or herself that all CONTRACTOR furnished traffic signal and street lighting items are prequalified and included on the ENGINEER's list of pretested and acceptable traffic signal and street lighting items prior to submitting a bid for the work. The OWNER reserves the right for up to thirty (30) days of evaluation before notification of results. Acceptance under these specifications for pregualification shall be at the discretion of the ENGINEER.

#### 420.4.1.4 EXCEPTIONS TO THE

SPECIFICATIONS: Any changes in the specifications must be in writing as an addendum issued prior to the opening of bids. Verbal explanations or instructions given prior to opening of bids will not be binding.

420.4.1.5 WARRANTY: Guarantees and warranties shall be in accordance with Section 13 - Warranty and

# GENERAL CLAUSES FOR TRAFFIC SIGNAL AND STREET LIGHTING SYSTEMS

Guarantee, Tests and Inspections, Corrections, Removal, or Acceptance of Defective Work. All manuals, drawings, shop drawings, wiring diagrams, etc. furnished by the electrical equipment manufacturer shall be transferred to the ENGINEER.

#### 420.4.2 BACKFILL MATERIALS

420.4.2.1 Backfill materials for signal and lighting system excavations within the roadway prism or for foundations shall be suitable for compaction as required under Section 510-Concrete Structures.

420.4.2.2 Excavation for conduit or drilling pits outside the roadway prism and in natural ground may be backfilled with the material originally removed except that it shall be free of large stones (over 4 inches in diameter), large pieces of concrete, vegetation, and other extraneous substances.

420.4.2.3 The CONTRACTOR shall provide sources for suitable backfill material.

# 420.4.3 PAVEMENT AND SIDEWALK MATERIAL:

420.4.3.1 Pavement and sidewalk replacements for signal and lighting system excavations shall conform to the existing material removed. If the original pavement design or concrete mix cannot be determined, the pavement design shall be determined by the ENGINEER and the sidewalk shall be in accordance with Section 340-Portland Cement Concrete Curbs, Gutters, Walks, Drivepads, Alley Intersections, and Median Paving.

420.4.3.2 Commercial sources may be used when approved by the ENGINEER. The CONTRACTOR shall submit material specifications and sample material when requested by the ENGINEER and as specified in Section 1502 - Submittals.

420.5 CONSTRUCTION REQUIREMENTS.

#### 420.5.1 GENERAL

420.5.1.1 Electrical work shall conform to NEC requirements and to any applicable local ordinances. The CONTRACTOR shall obtain a permit from the State Electrical Board (or equivalent state or local agency) prior to constructing the traffic signal or street lighting systems or any other electrical installations required by the contract and provide proof to the ENGINEER before work begins. Only licensed electricians shall be employed to perform electrical work and install electrical materials required by the contract. In addition, the CONTRACTOR shall obtain approval from the electric utility for the exact location of the electric service before its installation. Prior to final inspection of the project, the CONTRACTOR shall submit evidence to the ENGINEER that all electrical work and installations have been inspected and approved by an authorized representative of the State Electrical Board. All systems shall be complete and in operation to the satisfaction of the ENGINEER at the time the work is accepted.

420.5.1.2 It shall be the CONTRACTOR'S responsibility to know the requirements of the NEC (and all local requirements) and to notify the ENGINEER promptly of any conflicts with these specifications and/or the plans. In the event revisions to NEC requirements create a conflict with requirements in these specifications and/or the plans, the NEC requirements shall apply.

# 420.5.2 EXCAVATION AND BACKFILL

420.5.2.1 Excavation required for the installation of conduit, foundations, and other items shall be done so as to cause the least possible damage to streets and highways. Excavating shall not be done until immediately before installation of conduit and foundations and shall be approved by the ENGINEER.

420.5.2.2 There shall be no cutting of existing pavement unless approved by the ENGINEER.

420.5.2.3 Excavations within the roadway prism, including sidewalk areas, paved driveways and median areas and all standard (pole) foundations, shall be in accordance with Section 510-Concrete Structures.

420.5.2.4 Backfill of excavations in natural ground or out of defined roadway prism may be of original material, mechanically tamped, and neatly leveled to original grade. For excavations in grassed (landscaped) areas, the CONTRACTOR shall carefully remove sod prior to excavation and replace it after backfilling.

420.5.2.5 Fine grained material, all of which passes a 3/8 inch sieve, shall be placed a minimum of two (2) inches on the sides and above all conduit for the width of the trench to prevent damage to conduit during backfilling. This material shall also be placed as a two (2) inch cushion below the conduit when the bottom of the trench contains rocks or material determined unsuitable

# GENERAL CLAUSES FOR TRAFFIC SIGNAL AND STREET LIGHTING SYSTEMS

by the ENGINEER.

# 420.5.3 EXISTING AND TEMPORARY TRAFFIC SIGNALS AND LIGHTING SYSTEMS

420.5.3.1 The CONTRACTOR shall furnish, install, and maintain temporary traffic signals and lighting systems when shown on the plans or provided for in the specifications. The CONTRACTOR shall provide the ENGINEER access to all power disconnects and control equipment during this period. Timing plans for temporary traffic signals shall be as determined by the ENGINEER, or his designee. Unless otherwise called for on the plans or specifications, this temporary equipment will be retained by the CONTRACTOR after removal.

420.5.3.2 Existing signal and lighting systems shall be kept in operation until the new material is installed and ready for operation, unless otherwise permitted as noted on the traffic control plan. In this event, the CONTRACTOR shall not proceed with any work which will cause the existing signals to become inoperative until he has all materials for the new installation on hand, and the specified regulatory signing or temporary signals are in place and approved by the ENGINEER.

420.5.3.3 The scheduling of shutdowns shall be in accordance with the construction traffic control plan; the CONTRACTOR shall notify the ENGINEER in writing at least two (2) working days in advance. In the event of construction problems making this not feasible, the ENGINEER shall be notified and the work performed as he directs.

420.5.3.4 Existing signal material which is called for on the plans for removal and salvage shall be handled carefully to avoid damage and shall be delivered by the CONTRACTOR to the OWNER or as called for on the plans. Prior to beginning removals, the CONTRACTOR shall meet with ENGINEER at the project site to inventory and video tape existing equipment. The CONTRACTOR shall provide VHS format video camera and tape for the inventory. The original video tape shall be given to ENGINEER.

420.5.3.5 Salvaged lighting material will be removed by the electric utility unless otherwise noted on the plans. In this event, the CONTRACTOR shall remove and deliver the material to the location called for on the plans.

420.5.3.6 When the work requires additions or modifications to existing signal or lighting systems, the

CONTRACTOR shall give the ENGINEER at least two (2) workings days advance written notice of any interruptions and the ENGINEER shall be given the opportunity to inspect all work before and after re-energizing.

The electrical energy costs, maintenance and 420.5.3.7 operational responsibility for existing signal and lighting systems undergoing contract modifications shall remain with the OWNER or as otherwise designated on the plans. The CONTRACTOR shall retain responsibility for workmanship and all new material per this Section 420. Damage to existing equipment as a result of the construction activities shall be repaired immediately by the CONTRACTOR at no additional cost. If ENGINEER responds on an emergency basis to ensure public safety, the CONTRACTOR shall be responsible for all costs associated with the repair of the signal. All electrical energy costs for new signal and lighting systems shall be the responsibility of the OWNER. The CONTRACTOR shall ensure that the OWNER is the customer of record for the electric utility.

420.5.3.8 New signal and lighting systems or modifications to existing systems shall require a thirty (30) day installation test per this Section 420. Maintenance of new signals and lighting systems shall be the responsibility of the CONTRACTOR until partial acceptance is granted as defined in this Section 420. Upon granting of final acceptance, OWNER will be responsible for the signal and lighting systems.

420.5.3.9 After the signal has been placed in operation and prior to final acceptance, the CONTRACTOR shall ensure that the signal remains fully operational. The CONTRACTOR shall notify the ENGINEER immediately if the signal malfunctions or is otherwise disabled. OWNER may respond on an emergency basis to ensure safe operation of the signal system. If OWNER responds to such an emergency, the CONTRACTOR will be responsible for all costs associated with the repair of the signal.

420.5.3.10 Repairs or replacement of damaged signal and lighting systems shall be done in accordance with Section 13-Warranty and Guarantee, Tests, and Inspections, Corrections, Removal, or Acceptance of Defective Work

420.5.4 TESTING.

420.5.4.1 WIRING TEST

# GENERAL CLAUSES FOR TRAFFIC SIGNAL AND STREET LIGHTING SYSTEMS

420.5.4.1.1 Before acceptance of the work, the CONTRACTOR shall make the following tests on all lighting and signal circuits:

- 1. Test for continuity of each circuit.
- 2. Test for grounds in each circuit.
- 3. A megger test on each circuit between the circuit and ground; the insulation resistance for all vehicle loops, direct burial wire or cable.
- 4. When requested by the ENGINEER, a functional test to demonstrate that all parts of the system functions as specified or intended.

420.5.4.1.2 The initially applied voltage for the tests shall not be greater than the rated voltage of the cables, and the rate of increase shall be approximately uniform and not more than 100 percent in 10 seconds or less than 100 percent in 60 seconds.

420.5.4.1.3 Any fault in materials or in any part of the installation revealed by these tests shall be replaced or repaired by the CONTRACTOR in a manner satisfactory to the ENGINEER, and the same test shall be repeated until no fault appears.

420.5.4.1.4 Tests shall be performed under the surveillance of the ENGINEER. The CONTRACTOR shall furnish all instruments and personnel required for the test.

#### 420.5.4.2 OPERATION TESTS

420.5.4.2.1 A thirty (30) day operational test period is required and will start when the traffic signal is completely installed and fully operational, including loop detectors. The CONTRACTOR shall request approval to start the thirty (30) day operational test period in writing to the ENGINEER. Partial acceptance of the system will be granted upon satisfactory completion of the thirty (30) day operational test period. Final acceptance will be in accordance with Section 14-Payments to the CONTRACTOR and Completion.

420.5.4.2.2 Shop testing of the controllers shall be in accordance with Section 429-Traffic Signal Controllers. This special testing is in addition to the thirty (30) day installation tests.

420.5.4.2.3 Timing for signal controllers during the installation test period shall be determined by the ENGINEER. No signal shall be placed in operation until the ENGINEER has verified the time settings and the correctness of all signal indication outputs. The CONTRACTOR shall provide access to the signal controller for the ENGINEER during the test period.

420.5.5 TECHNICAL ASSISTANCE

420.5.5.1 ENGINEER is available to answer CONTRACTOR'S technical questions on electrical equipment on an as needed basis.

420.5.5.2 The CONTRACTOR shall make any requests for assistance to the ENGINEER. The ENGINEER will then make the determination as to need. Assistance will be limited to verbal explanations on lab testing failures, deficiencies, wiring diagrams, electronic schematics, controller, related equipment hook-up, and trouble shooting procedures. OWNER's employees will not perform any physical labor for rewiring, repairs or modifications during the test period or prior to final acceptance, except when required to maintain public safety.

420.6 MEASUREMENT AND PAYMENT: Measurement and payment of furnishing and installing traffic signal and street lighting systems will be as specified in the bid proposal.

### SIGNAL AND LIGHTING SERVICE SYSTEMS

421.1 GENERAL: This work shall consist of furnishing and installing service poles, service connections, and lighting control cabinets in compliance with the specifications, details shown on the plans, and Standard Drawings at the locations shown on the plans, or as established by the ENGINEER.

421.2 REFERENCES

- 421.2.1 American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications, Latest Edition
- M133 Preservative and Pressure Treatment Process for Timber
- 421.2.2 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition
- A36 Structural Steel
- A307 Carbon Steel Bolts and Studs; 60,000 psi Tensile
- 421.2.3 National Electrical Code (NEC), Latest Edition
- 421.2.4 National Electrical Manufacturers Association (NEMA) Standards, Latest Edition
- 421.2.5 Underwriters Laboratories
- 421.2.6 This Publication, Latest Edition

SECTION 101 PORTLAND CEMENT CONCRETE

- SECTION 102 STEEL REINFORCEMENT SECTION 420 GENERAL CLAUSES FOR TRAFFIC SIGNAL AND STREET LIGHTING SYSTEMS
- SECTION 501 EXCAVATIONS AND BACKFILL FOR STRUCTURES
- SECTION 701 TRENCHING, EXCAVATION, AND BACKFILL
- SECTION 1502 SUBMITTALS
- 421.3 MATERIALS.

421.3.1 SERVICE POLE

421.3.1.1 Materials for service poles shall conform with the details shown on the plans and the requirements in the special provisions. Timber poles treated in conformity with the requirements of AASHTO M 133 shall be provided. The pole shall be of the size called for on the plans and as a minimum shall be butt treated.

421.3.1.2 Normal service requirements for traffic signals shall be 120/240-volt, 60-cycle, 3-wire solid neutral power, and for multiple lighting systems shall be 240/480-volt, 60-cycle, 3-wire solid neutral power, unless otherwise specified in the plans or special provisions.

421.3.1.3 Service switches, when required, shall be a circuit breaker type or a disconnect switch, type HD, with fuses, with capacity and ratings as shown on the plans or in the special provisions. The service switch shall be enclosed in a NEMA rain-tight housing with a hinged cover. The cover shall stay in position when open and shall have a hasp for a padlock. The switch and housing shall be approved by UL.

421.3.2 SERVICE RISER: Materials for service risers shall conform with the requirements of this Section 421 and details shown on the plans, when electrical service is to be installed on an existing pole.

421.3.3 METER PEDESTAL

421.3.3.1 Materials for meter pedestals shall conform with the details shown on the plans, the requirements of the NEC, and the following requirements:

421.3.3.2 Meter pedestals shall be constructed of 14 gauge steel with corrosion resistant finish.

421.3.3.3 Meter socket shall have a minimum rating of 100 amp and be factory wired in separate wireway from terminal block to meter socket.

421.3.3.4 For services larger than 100 amp, a factory-rated 200 amp pedestal shall be used.

421.3.3.5 Insulated stud terminal blocks or bus pads shall be used to accommodate connectors.

4213.3.6 Pedestal bonding lug grounding conductors must be continuous to the breaker panel grounding terminal.

421.3.3.7 Termination section shall have a removable rain-tight cover with provision for padlocking over captive pentahead bolt. All other removable portions of termination section must be sealable.

421.3.3.8 Meter pedestal shall be anchored securely to concrete foundation. Concrete foundation and anchoring system shall conform with the details shown on the plans or as shown herein.

421.3.4 SERVICE CONNECTION: Service connections (connection to existing service pole, service riser, transformer, or meter pedestal) shall conform with the details shown on the plans and the requirements of the NEC.

421.3.5 LIGHTING CONTROL CABINET

421.3.5.1 Materials for lighting control cabinets shall conform with the details shown on the plans, the requirements of the NEC, and the following requirements:

421.3.5.2 Cabinets shall be fabricated from 14 gauge steel with a durable finish consisting of a corrosion resistant durable finish.

421.3.5.3 Cabinets shall be REA approved, ground mounted, tamper proof, and lockable.

421.3.5.4 Cabinets shall be suitable for 25KV systems with ground nut and ground lug.

421.3.5.5 Cabinet hardware shall be stainless steel including hinges.

421.3.5.6 Mounting brackets shall be furnished for attaching contactors, photo electric cells, junction boxes and other auxiliary equipment.

421.3.5.7 Lighting Control Cabinet shall be anchored securely to concrete foundation. Concrete foundation and anchoring system shall conform with details shown on the plans.

421.3.6 PHOTOELECTRIC CONTROLLER

421.3.6.1 Materials for photoelectric controllers shall comply with the details shown on the plans.

421.3.6.2 The photoelectric unit shall consist of a light-sensitive element connected directly to an internal control relay without intermediate amplifications. The unit may be either the horizontal-sensing or zenith-sensing type and shall have turn-on at  $1.5 \pm 0.5$  horizontal foot-candles and a turn-off at a maximum of 5.6 foot-candles with a minimum difference of 0.8 foot-candle between turn-on and turn-off. The load rating shall be 1800 watts minimum (Lighting load).

421.3.6.3 The base of the unit shall be provided with a seven pin ANSI twist-lock type plug mounting which will enable the unit to be mounted directly on luminaires or by the use of an adapter base on pole tops or sides. The controllers shall normally work in conjunction with external auxiliary load relays for handling required lighting and auxiliary loads.

421.3.6.4 Unless otherwise specified, the supply voltage rating shall be the same as the system voltage noted on plans. The minimum operating temperature range shall be -40 degrees F to 140 degrees F. The power consumption of the controller shall be less than 12 watts.

421.3.6.5 When the north sky illumination in the area falls to a preset value, the lighting load shall be turned on. A potentiometer to vary the turn-on value within the operating range shall be easily accessible for adjustment. A time delay shall be incorporated into the circuit to prevent street lights from being turned off at night by transient lights which might be focused on the controller. The controlled lighting load shall remain on or become energized in the event of any functional failure of the electronic circuit. The controller shall be equipped with a lightning arrestor capable of handling 500V at 35,000 amps.

# 421.3.7 AUXILIARY CONTACTOR

421.3.7.1 The contactor shall work in conjunction with a photoelectric controller and the specified lighting loads. The contactor shall be normally open and shall be double-pole, unless otherwise specified.

421.3.7.2 The contactor shall be of the electrically held type, designed to withstand lamp load inrush current and to carry full rated current on a continuous basis. The operating voltage and load rating shall be as noted on the plans.

421.3.7.3 A three position switch to permit manual operation of the lighting circuit shall be provided. The switch shall be furnished and installed with an indicating nameplate reading

"PHOTO-OFF-MANUAL." The switch shall be toggle or rotary type, double-pole, triple-throw, center-off position, and shall be rated as required on the plans.

# 421.4 CONSTRUCTION REQUIREMENTS.

#### 421.4.1 GENERAL

421.4.1.1 Service points shown on the plans are approximate. The CONTRACTOR shall obtain the exact location from the electric utility. The ENGINEER shall approve the final location before any service installation work is started. In the event a major change in location from that shown on the plans is required, the ENGINEER will determine the final location and the service run will be adjusted as per the contract unit price.

# SIGNAL AND LIGHTING SERVICE SYSTEMS

421.4.1.2 The CONTRACTOR shall obtain all necessary permits and electrical inspections required for service attachment. Approval of the ENGINEER shall be given before hook-up.

421.4.1.3 The CONTRACTOR shall have the OWNER shown as the customer of record for the electric utility in accordance with Section 420-General Clauses for Traffic Signal and Street Lighting Systems.

421.4.2 SERVICE POLE

421.4.2.1 Conduit shall be attached to the pole as shown on the plans. Where necessary, condulets, covers, and gaskets shall be provided and installed.

421.4.2.2 Conduit used in the service installation above ground shall be rigid steel, galvanized-type of the size specified on the plans or in the special provisions. In areas where rigid steel conduit is coupled to rigid PVC conduit used for the underground portion of the service run, joining of the conduits shall take place underground from two (2) inches to ten (10) inches below the surface. The conduit shall be securely bonded to the surface pole and the service pole ground system as required by the NEC.

421.4.2.3 Conduit, switches, and other necessary material shall be mounted on the service pole as shown on the plans. When called for, the backing board shall be 3/4-inch thick Douglas Fir Grade B-B or better exterior type plywood. The plywood shall be painted two coats of approved exterior grey paint for weatherproofing. Special care shall be taken to insure that the edges of the plywood are well sealed against moisture and general weathering.

421.4.2.4 The layout, connections, and mounting details of the various switches and associated equipment shall be as shown on the plans or as indicated in the special provisions. All switches, fittings, and necessary equipment shall be furnished and installed.

421.4.2.5 Meter sockets as required by the service utility company shall be furnished and installed as shown on the plans. The service utility company will supply and install meters.

421.4.3 SERVICE RISER: Service risers and/or underground services shall be shown and installed at locations shown on the plans. The installation of service risers shall conform to the requirements of this Section 421 and details shown on the plans. Service risers shall be installed on the quadrant of the existing pole as shown on the plans or as designated by the service utility company.

421.4.4 METER PEDESTAL: Meter pedestals shall be installed at locations shown on the plans and a minimum of ten (10) feet from the service pole. The installation of meter pedestals shall conform to the details shown on the plans.

421.4.5 SERVICE CONNECTION: Service connections shall be installed at an existing service pole, service riser, meter pedestal, or at a location shown on the plans. The installation of service connections shall conform to the details shown on the plans.

421.4.6 LIGHTING CONTROL CABINETS: Lighting control cabinets shall be installed at locations shown on the plans or determined by the ENGINEER. The cabinets shall be installed plumb on a concrete foundation with necessary grout or caulking to provide a weather resistant, dust tight installation. The installation of lighting control cabinets shall conform to the details shown on the plans.

### 421.5 MEASUREMENT AND PAYMENT.

421.5.1.1 Measurement of service poles including all materials shown on the plans, either with or without meter sockets and disconnect switches, will be measured by the unit complete in place.

421.5.1.2 Measurement of service risers including all materials shown on the plans, either with or without meter sockets and disconnect switches, will be measured by the unit complete in place.

421.5.1.3 Measurement of meter pedestals including concrete foundation will be measured by the unit complete in place.

421.5.1.4 Measurement of service connections will be measured by the unit complete in place.

421.5.1.5 Measurement of lighting control cabinets, including concrete foundation and all materials shown on the plans, will be measured by the unit complete in place.

421.5.2 The accepted quantities of service poles, service risers, meter pedestals, service connections, and lighting control cabinets will be paid for at the contract price per unit of measurement for each of the pay items listed as shown on the bid proposal.

#### SIGNAL AND LIGHTING STANDARDS

422.1 GENERAL: This work shall consist of furnishing and installing traffic signal standards, street lighting standards, and anchor bolts, in compliance with the specifications, details shown on the plans, and Standard Drawings at the locations shown on the plans, or as established by the ENGINEER.

422.2 REFERENCES.

- 422.2.1 National Electrical Code (NEC), Latest Edition
- 422.2.2 Aluminum Association Standards, Latest Edition
- 422.2.3 American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications, Latest Edition
- 422.2.4 American National Standards Institute (ANSI) Standards, Latest Edition
- 422.2.5 IES (International illuminating Standard) Road Way Standard

#### SECTION 300 Stainless Steel

- 422.2.6 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition
- A36 Structural Steel
- A123 Zinc Coating on Product Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strips
- A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- A307 Carbon Steel Bolts and Studs; 60,000 psi Tensile
- A325 High-Strength Bolts for Structural Steel Joints
- B108 Aluminum-Alloy Permanent Mold Castings
- B221 Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes
- M314 Steel Anchor Bolts
- 422.2.5 National Electrical Manufacturers Association (NEMA) Standards, Latest Edition
- 422.2.6 This Publication, Latest Edition:

# SECTION 101 PORTLAND CEMENT CONCRETE SECTION 102 STEEL REINFORCEMENT SECTION 501 EXCAVATION AND BACKFILL FOR

#### STRUCTURES SECTION 701 TRENCHING, EXCAVATION, AND BACKFILL SECTION 1502 SUBMITTALS

#### 422.3 MATERIALS.

422.3.1 STANDARD: A standard will consist of a shaft with a base, anchor bolts, mast arms (if required), and other hardware required to support the traffic signal and highway lighting apparatus.

Types of standards are as follows:

- (a) Type I. A pedestal type support for traffic signals, controller cabinets, and splice cabinets.
- (b) Type II. A mast arm traffic signal support including shaft, arm, and hardware.
- (c) Type III. A combination mast arm traffic signal and roadway luminaire support.
- (d) Type IV. A post top luminaire support.
- (e) Type V. A mast arm luminaire support.
- 422.3.1.1 Type I Standard

422.3.1.1.1 The pedestal type support shall be a threaded pole and a threaded (female) square cast aluminum base assembly with set screw(s) as detailed on the plans. The aluminum base shall be a break-away design approximately 15 inches high and shall have a covered hand hole of 8 inches x 8" inches minimum dimension.

422.3.1.1.2 The pole may be fabricated from steel and may be either 4-inch nominal diameter pipe, Schedule 40, or a tapered steel shaft of equal or greater wall thickness.

422.3.1.1.3 Type I Standard. Two Foot: shall be designed to support a post top mounted traffic signal controller or splice cabinet weighing 150 pounds with a projected area of 5 square feet.

422.3.1.1.4 Type I Standard. Ten Foot: shall be designed to support an assembly of traffic signals and signing mounted at the top of the support weighing 150 pounds with a projected area of 15 square feet.

422.3.1.1.5 Type I Standard. Thirteen Foot: shall be designed to support an assembly of traffic signals and signing mounted at the top of the support weighing 150

### SIGNAL AND LIGHTING STANDARDS

pounds with a projected area of 15 square feet.

422.3.1.1.6 Type I Standard. Fifteen Foot: shall be designed to support an assembly of traffic signals and signing mounted at the top of the support weighing 150 pounds with a projected area of 15 square feet.

# 422.3.1.2 Type II Standard

422.3.1.2.1 Standards shall be a "trombone" truss arm design fabricated from either steel or aluminum as designated on plans, in conformance to details on the plans and these specifications. Standards shall in addition conform to the member attachment and size details in the plans for interchange ability and standardization between fabricators.

422.3.1.2.2 Design Requirements

423.3.1.2.2.1 The standard installation shall be designed to support traffic signal heads, back plates, and signing as designated on the Standard Drawings.

423.3.1.2.2.2 Structures shall be designed according to the requirements of the latest edition of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

#### 422.3.1.2.3 Shaft

422.3.1.2.3.1 Steel shafts shall be fabricated from a weldable grade hot rolled steel, having a yield point, after fabrication, of not less than 55,000 pounds per square inch and a wall thickness not less than No. 7 U.S. Standard Gauge (0.1793 inch). The shaft may be round in cross section and tapered at a constant rate. After fabrication, the steel shaft shall be hot dip galvanized according to the requirements of ASTM A 123 and shall be cleaned to provide a uniform and stain free surface. Scratches shall be repaired in the field with an approved paint.

422.3.1.2.3.2 Aluminum shafts shall be fabricated from seamless round tapered tubing of alloy 6063-T6 or 6005-T5 conforming to the requirements of ASTM B 221, having a thickness not less than 0.188 inch. The shaft shall have no welds except at the lower end joining the shaft to the flange base. The shaft shall be finished by mechanical means providing a uniform appearance and shall not require any surface preparation at the time of installation.

422.3.1.2.3.3 A removable pole top cap or mast arm hand hole with cover shall be provided to allow access for the pulling of cable through the shaft.

#### 422.3.1.2.4 Arm

422.3.1.2.4.1 "Trombone" truss arms for Type II standards shall be fabricated from either steel or aluminum as designated on the plans. Material and finish shall be as specified for the shaft except that steel members shall all have a minimum thickness of No. 11 U.S. Standard Gauge (0.1196 inch) and aluminum tubing used in the fabrication shall have a minimum thickness of 0.156 inch.

422.3.1.2.4.2 Length and position of arms shall be as shown on the plans. Arms shall be attached securely to shafts in accordance with details in the plans.

### 422.3.1.2.5 Transformer Base

422.3.1.2.5.1 Steel transformer bases shall be fabricated from hot rolled mild steel having a yield point of not less than 33,000 pounds per square inch and side wall thickness of not less than No. 7 U.S. Standard Gauge (0.1793 inch). The steel transformer base shall be galvanized after fabrication to the requirements of ASTM A 123.

422.3.1.2.5.2 Aluminum transformer bases shall be a one-piece casting of aluminum alloy 356-T6 complying with the requirements of ASTM B 108.

422.3.1.2.5.3 The bases shall be not less than 20 inches in height and shall have a hand hole with cover of not less than 8 x 12 inches in size, in one side. The transformer bases shall be designed to permit the shaft to be rotated a full 360 degrees and to be aligned irrespective of anchor bolts placement, in conformance to details in the plans.

422.3.1.2.6 Hardware: Hardware must be either steel or stainless steel. Steel hardware shall conform to the requirements of ASTM A 307 or A 325 and shall be galvanized in accordance with the requirements of ASTM A 153. Stainless steel hardware shall conform to ANSI 300 series stainless steel.

#### 422.3.1.2.7 Anchor Bolts

422.3.1.2.7.1 Four anchor bolts shall be furnished with each standard. The bolts may be fabricated from high strength steel bars with a guaranteed minimum yield strength of 55,000 pounds per square inch or steel meeting the requirements of AASHTO M 314. Unless otherwise detailed in plans, the bolts shall be of sufficient size and length to support the structure with the design loads, in accordance to the AASHTO Specifications.

### SIGNAL AND LIGHTING STANDARDS

422.3.1.2.7.2 The top of each bolt shall be threaded no less than 8 inches, and the full thread plus 6 inches shall be hot dipped galvanized. Each anchor bolt shall have an "L" bend at the bottom. One leveling nut and one hold-down nut shall be provided with each bolt.

422.3.1.3 Type III Standard: Type III standards shall be fabricated from steel and shall conform to the requirements for Type II standards. In addition, Type III standards shall support a luminaire by means of a shaft extension and arm in accordance with the details shown on the plans. Each arm shall be designed to support a luminaire of 75 pounds and a projected area of 3.3 square feet. The shaft extensions shall conform to the requirements for Type II standards, except that steel shaft extensions may have a minimum thickness of No. 11 U.S. Standard Gauge (0.1196 inch).

#### 422.3.1.4 Type IV Standard

422.3.1.4.1 Unless otherwise specified on the plans or in the special provisions, Type IV standards shall comply with the requirements for Type V standards, except that a mast arm will not be included on Type IV standards. The shaft shall include a tenon for luminaire mounting.

422.3.1.4.2 When laminated wood, concrete, and fiberglass standards are called for in the plans, only that material shall be used for fabrication, in conformance to the plans and special provisions.

422.3.1.5 Type V Standard

422.3.1.5.1 Standards shall be tapered shafts with davit type mast arm (unless otherwise called for on the plans) and in conformance with the dimensions and details on the plans. Unless otherwise called for in the plans or these specifications, breakaway bases shall be provided.

422.3.1.5.2 Design Requirements

422.3.1.5.2.1 The installation shall be designed according to the requirements of the latest edition of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. Each arm shall be designed to support a luminaire weighing 60 pounds and a projected area of 3.3 square feet.

422.3.1.5.2.2 The following tolerance for straightness of poles shall not be exceeded:

TOTAL MOUNTING H	EIGHT STRAIGHTNESS (INCHES)
20	0.75
20	0.75
30	1.00
35	1.25
40	1.50
50	1.75

422.3.1.5.2.3 Dead load deflection should be limited in accordance to AASHTO Specifications.

422.3.1.5.2.4 The standard may be fabricated of spun aluminum, or galvanized steel as designated on the plans.

422.3.1.5.3 Spun Aluminum.

422.3.1.5.3.1 Shaft: Shafts shall be one-piece, seamless tapered tubes of aluminum alloy 6063 and shall have a final mechanical strength of not less than T6 temper after fabrication. The shaft shall have a wall thickness of not less than 0.188 inch for 40-foot mounting height or less than 0.219 inch for a mounting height greater than 40 feet. The shaft shall have no longitudinal welds and only two circumferential welds which will be located at the lower end for joining the shaft to the anchor base. A one-piece cast aluminum anchor base of aluminum alloy 356-T6 shall be secured to the base. All exposed edges of the plate which make up the base assembly shall be finished smooth, and each base shall be furnished with four bolt covers. The shaft shall be rotary sand polished and wrapped for protection during handling and shipping.

422.3.1.5.3.2 Mast Arm: Mast arms shall consist of seamless aluminum tubing, aluminum alloy 6063-T6, of the length and shape shown on the plans. Arms shall be attached to the shaft by means of a slip fitter and held in place by bolts as designated on the Standard Drawings. Davit arms shall be installed per manufacturer's recommendations to prevent rotation under wind loads. If arms rotate after erection, the CONTRACTOR shall lower the Type V standard, reassemble the arm, and reinstall the Type V standard with the arm in the proper position.

422.3.1.5.3.3 Hardware: Hardware shall be stainless steel.

422.3.1.5.3.4 Welding: Welding shall conform to the requirements of "Specifications for Aluminum Bridge and Other Highway Structures" published by the Aluminum Association.

422.3.1.5.4 Galvanized Steel.

### SIGNAL AND LIGHTING STANDARDS

#### 422.3.1.5.4.1 Shaft

422.3.1.5.4.1.1 Shafts shall be fabricated from steel having a yield strength of not less than 40,000 pounds per square inch after fabrication, with a minimum wall thickness of No. 10 U.S. Standard Gauge (0.1345 inch), except that shafts with an after fabrication yield strength of 55,000 pounds per square inch or greater may have a minimum wall thickness of No. 11 U.S. Standard Gauge (0.1196 inch). The shaft shall be round in cross section and tapered at a constant rate.

422.3.1.5.4.1.2 The shaft shall be one section, except that for mounting heights greater than 50 feet, a two section design with a top section that will slip-fit over the bottom section a minimum length of  $1\frac{1}{2}$  times the diameter at the point of overlap will be accepted. The shaft section(s) shall be formed into a continuous weld. The shaft shall be attached by two circumferential welds to a baseplate. The base shall be either a one-piece steel casting or fabricated from steel plate with a minimum yield strength of 36,000 pounds per square inch, conforming to any details on the plans.

422.3.1.5.4.2 Galvanizing and Finishing: All exposed welds except fillet welds shall be ground flush with the base metal. All steel poles shall be fully galvanized after fabrication to the requirements of ASTM A 123. After galvanizing, the poles shall be cleaned to provide a uniform and stain-free surface. All scratches due to erection and handling shall be repaired in the field with an approved paint.

422.3.1.5.4.3 Mast Arm: Arms shall be fabricated from the same material as the shaft and shall have a wall thickness of no less than No. 11 U.S. Standard Gauge (0.1196 inch). The separate section davit arm shall be attached by a slip fitter fixed into the shaft or arm and held by stainless steel screws, in conformance to any details in the plans. Davit arms shall be installed per manufacturer's recommendations to prevent rotation under wind loads. If arms rotate after erection, the CONTRACTOR shall lower the Type V standard, reassemble the arm, and reinstall the Type V standard with the arm in the proper position.

422.3.1.5.4.4 Anchor Bolts: Four steel anchor bolts shall be furnished with each Type V standard and shall be fabricated from steel meeting AASHTO M 314 or from other steel with a minimum yield point of 55,000 pounds per square inch. The top of the anchor bolts shall be threaded for approximately 9 inches and shall be galvanized for a minimum of 12 inches. Each anchor bolt shall be furnished with nuts and washers as required for breakaway base utilized or one nut, washer and shim(s) if

anchor type base.

422.3.1.5.4.5 Breakaway Bases

422.3.1.5.4.5.1 Unless otherwise noted on the plans, all Type V standards shall be designed to meet requirements for dynamic performance under vehicle impact as specified in the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. All bases shall be designed for a 16-inch diameter anchor bolt circle, unless otherwise noted on plans.

422.3.1.5.4.5.2 Type V standards located behind a barrier or bridge rail and so noted on the plans shall have an anchor base for direct, rigid mounting.

422.3.1.5.4.5.3 Steel standards may utilize a steel slip base or breakaway couplings conforming to the details in the plans. If the total weight of the standard and the luminaire assembly exceeds 600 pounds the CONTRACTOR shall furnish evidence of compliance in the form of test data obtained in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

422.3.1.5.4.5.4 Aluminum standards may utilize either a cast aluminum base or breakaway coupling, conforming to details in the plans. When requested by the ENGINEER, the CONTRACTOR shall furnish evidence of compliance in the form of test data obtained in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. The cast aluminum base shall be inserted a minimum of 12 inches into the shaft and shall be bonded to the shaft with weatherproof structural adhesive to fully develop the required strength.

422.3.1.5.4.5.5 Breakaway couplings shall be designed to be placed between the anchor bolts and the pole base, and of a frangible material that will breakaway under impact (shear). The coupling shall conform to the design and material detailed on the plans. The tensile or compressive strength of the coupling shall equal or exceed that required for the design wind loading of the furnished Type V standard.

422.3.1.5.4.5.6 The coupling installation shall include a "skirt" base cover of a material and design conforming to details on the plans.

422.4 CONSTRUCTION REQUIREMENTS.

422.4.1 Installation shall include the erection of standards complete as shown on the plans, leveling of

#### SIGNAL AND LIGHTING STANDARDS

standards, any required grouting between standard bases and foundations, and the installation of anchor bolts in foundations.

422.4.2 All threaded holes and hubs shall be retapped and sealed against rust by heavy grease or other type of preservative. Required field-made holes (such as for mounting pedestrian push buttons) shall be neatly drilled. Use of a cutting torch will not be permitted.

422.4.3 When torque values are called for on the plans for anchor bolt nuts, breakaway couplings or slip bolts, the CONTRACTOR shall make all adjustments with an approved torque wrench. No other values shall be used unless approved by the ENGINEER.

422.4.4 New foundations for signal and lighting standards will be constructed in accordance with Section 423 - Foundations for Signal and Lighting Installations.

422.4.5 Existing signal and lighting standards to be relocated shall not be removed until new foundations are in place and are accepted by the ENGINEER. The CONTRACTOR shall give the ENGINEER at least five working days notice before removing and resetting designated signal and lighting standards. All shop drawings and other documents of record on the existing in-place signal and lighting standards will be made available to the CONTRACTOR. All work and material required for rewiring relocated signal and lighting standards shall be included in this work.

422.4.6 Remove and Reset Street Lighting Standard & Luminaire: The CONTRACTOR shall construct new foundations for the Type V standards. The CONTRACTOR shall then remove the existing standards and luminaires and relocate standards and luminaires to the new foundations.

422.4.7 Remove and Reset Signal & Mast arms: The CONTRACTOR shall construct new foundations for the existing Type I or II Standards. The CONTRACTOR shall then remove existing Type I or II standards, traffic signals, and mast arms and relocate the standards, traffic signals, and mast arms to the new foundations.

422.4.8 Remove Existing Foundations: Existing foundations for traffic signal equipment and luminaire standards shall not be removed until the new foundation and conduit system is complete in place and are functioning. The foundation to be removed shall be completely removed or removed to a minimum of 12 inches below grade and backfilled in accordance with Section 701-Trenching, Excavation, and Backfill or as shown on the plans or approved by the ENGINEER.

422.4.9 OWNER Furnished Standards, Mast arms & Roadway Luminaires. When indicated on the plans for the material to be furnished by the OWNER, the CONTRACTOR shall load, haul, and install OWNER furnished lighting standards, mast arms, and roadway luminaires of the types and at the locations designated on the plans in compliance with the Standards Specifications, and as directed by the ENGINEER.

422.5 MEASUREMENT AND PAYMENT.

422.5.1 Signal and lighting standards with anchor bolts will be measured by the unit complete in place.

422.5.2 Removing and resetting street lighting standard and luminaire will be measured by the unit complete in place.

422.5.3 Remove and reset signal standard and mast arm will be measured by the unit complete in place.

422.5.4 Installing OWNER furnished standards, mast arms and roadway luminaires will be measured by unit complete in place.

422.5.5 Anchor bolts will be measured by the unit complete in place, only when specifically designated on the plans and when signal and lighting standards are being furnished by others.

422.5.6 The accepted quantities of signal and lighting standards will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown on the bid proposal.

# FOUNDATIONS FOR SIGNAL AND LIGHTING INSTALLATIONS

423.1 GENERAL: This work shall consist of constructing concrete foundations for support of traffic signal standards, luminaire standards, control cabinets, and ground mounted transformers, in compliance with the specifications, details shown on the plans, Standard Drawings, and at the locations shown on the plans, or as established by the ENGINEER.

- 423.2 REFERENCES
- 423.2.1 American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications, Latest Edition
- 423.2.2 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition
- A36 Structural Steel
- A307 Carbon Steel Bolts and Studs; 60,000 psi Tensile
- 423.2.3 National Electrical Code (NEC), Latest Edition
- 423.2.4 This Publication, Latest Edition

423.2.5 International Building Code (IBC), Latest Edition

SECTION 101 PORTLAND CEMENT CONCRETE SECTION 102 STEEL REINFORCEMENT SECTION 501 EXCAVATION AND BACKFILL FOR STRUCTURES SECTION 510 CONCRETE STRUCTURES SECTION 701 TRENCHING, EXCAVATION, AND BACKFILL

SECTION 1502 SUBMITTALS

# 423.3 MATERIALS:

423.3.1 Concrete design including cement, air entrainment, and other admixtures, water and aggregate shall conform with the requirements of Section 101 Portland Cement Concrete.

423.3.2 Concrete installation shall conform with the requirements of Section 510 - Concrete Structures. The design mix shall be provided to the ENGINEER for approval.

423.3.3 Steel reinforcement shall conform with the

requirements of Section 102 - Steel Reinforcement.

#### 423.4 CONSTRUCTION REQUIREMENTS.

423.4.1 Concrete foundations may be cast in place or precast. Foundations shall be placed on firm ground. Forms shall be true to line and grade, rigid, and securely braced. The concrete for each foundation shall be placed in one operation. Exposed portions of cast-in-drilled-hole foundations shall be formed to present a neat appearance. The forms and ground shall be thoroughly moistened before concrete placement.

423.4.2 Ground rods shall be installed as shown on the Standard Drawings.

423.4.3 A template shall be used to insure that conduit stubs and anchor bolts are held in proper position during concrete placement until the concrete has set. After placement and before setting of concrete, anchor bolts shall be raised and lowered individually to eliminate air pockets and distribute aggregate, and shall be aligned properly.

423.4.4 Exposed surfaces of concrete foundations shall receive a finish that is smooth, straight, and free of form marks.

423.4.5 Concrete foundations shall be backfilled according to the requirements of Section 501 - Excavation and Backfill for Structures and details in the plans. Proper drainage shall be provided on slopes. Backfilling will be considered incidental to the completion of the work and no measurement or direct payment will be made therefore.

423.4.6 When it is discovered during excavation for a concrete foundation that the location shown on the plans conflicts with existing underground or overhead utilities, a new location will be determined by the ENGINEER if possible. The ground surface at plans locations shall be restored to its original elevation. If the location cannot be changed, a new foundation design or utility relocation will be done as authorized by the ENGINEER.

423.4.7 Foundations shall be constructed as designated on the Standard Drawings unless the plans show otherwise or the ENGINEER directs otherwise. Foundations located in sidewalks shall be level with the surface of the sidewalk and shall conform with the "Americans with Disabilities Act". Expansion material

# FOUNDATIONS FOR SIGNAL AND LIGHTING INSTALLATIONS

shall be placed between the foundation and the sidewalk.

423.4.8 Foundations for standards with mast arms shall be carefully positioned so that the standards may be oriented as shown on the plans.

423.4.9 Foundations shall cure for a minimum of 7 days after concrete placement before signal and lighting standards are installed.

423.5 MEASUREMENT AND PAYMENT.

423.5.1 The accepted quantities of portland cement concrete and steel reinforcement for concrete foundations for signal standards, controller cabinets, and splice cabinets complete in place will be measured by the unit complete in place as shown on the bid proposal.

423.5.2 Concrete foundations for luminaries (including portland cement concrete and reinforcing steel) will be measured by the unit complete in place as shown on the bid proposal.

423.5.3 The accepted quantity of foundations for signal standards, controller cabinets, splice cabinets, and luminaries will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown on the bid proposal.

### ELECTRICAL CONDUIT

424.1 GENERAL: This work shall consist of furnishing and installing electrical conduit in compliance with the specifications, the details shown on the plans, and Standard Drawings at the locations shown on the plans, or as established by the ENGINEER.

424.2 REFERENCES.

- 424.2.1 American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications, Latest Edition
- 422.2.2 American National Standards Institute (ANSI) Standards, Latest Edition
- C80.1 Rigid Steel Conduit Zinc Coated
- 424.2.3 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition
- A36 Structural Steel
- A307 Carbon Steel Bolts and Studs; 60,000 psi Tensile
- D1248 Polyethylene Plastics Molding and Extrusion Materials
- D1785 Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120
- 424.2.4 National Electrical Code (NEC), Latest Edition
- 424.2.5 Underwriters Laboratories Standards, Latest Edition
- UL6 Safety Rigid Metal Conduit
- UL651 Safety Schedule 40 & 80 Rigid PVC Conduit UL1242 Safety Intermediate Metal Conduit

424.2.6 This Publication, Latest Edition

- SECTION 501 EXCAVATION AND BACKFILL FOR STRUCTURES
- SECTION 701 TRENCHING, EXCAVATION, AND BACKFILL

#### 424.3 MATERIALS

424.3.1 NONMETALLIC CONDUIT: Nonmetallic conduit shall be high-impact poly vinyl chloride (PVC) pipe, Schedule 40, Designation PVC 2110, conforming to the requirements of ASTM D 1785 or high density, Type

III polyethylene conduit conforming to ASTM D 1248-6. Conduit and fittings shall comply with the requirements of UL standards (Publication UL 651) and shall be stamped "UL approved." Nonmetallic conduit shall be used only for underground installations.

#### 424.3.2 METALLIC CONDUIT

424.3.2.1 Metallic conduit may be either rigid steel conduit (GRC) or intermediate metallic conduit (IMC). Rigid steel (GRC) shall conform to Underwriters Laboratories UL-6 specification, ANSI C 80.1 and Federal Specification WW-C-581E. Intermediate metallic conduit (IMC) shall conform to Underwriters Laboratories UL 1242 and Federal Specification WW-C-581E. Metallic conduit shall be hot-dipped galvanized to provide a corrosion resistant coating. Fittings shall be watertight and of the same material as the conduit. All conduit installed above ground shall be metallic.

424.3.2.2 Approved expansion couplings shall be provided for all metallic conduit. Expansion couplings shall be as recommended by the manufacturer, designed to compensate for linear thermal expansion of a run of metallic conduit. All expansion couplings shall make a watertight joint.

424.4 CONSTRUCTION REQUIREMENTS.

424.4.1 GENERAL

424.4.1.1 Electrical cable and wire shall be run in conduit except where run inside poles or where the plans show otherwise. All conduit used for underground installations shall be nonmetallic except where encased in concrete, such as bridge decks, or when called for on the plans. The CONTRACTOR may use conduit of a larger size than shown on the plans at no increase in cost provided the larger size is used for the entire run from outlet to outlet. Reducing couplings will not be permitted.

424.4.1.2 The CONTRACTOR shall plan the trenching and conduit placement operation to minimize the open trench and exposed conduit left overnight.

424.4.1.3 Routings of conduit runs shown on the plans are tentative and may be changed by the ENGINEER to avoid underground obstructions. Accurate records of any change from conduit locations shown on the plans shall be kept for preparation of as-built drawings, and the

# ELECTRICAL CONDUIT

details of altered conduit runs shall be submitted to the ENGINEER before final acceptance of the project.

424.4.1.4 Excavation (trenching) and backfill for all conduit shall be in accordance with the requirements of Section 701. Conduit shall be laid not less than 30 inches below the finished surface in street and driveway areas, top of curb in sidewalk areas, or natural ground line in unpaved areas. When approved by the ENGINEER, the conduit may be placed at not less than 18 inches below the surface elevation in unpaved median areas, open (natural ground) areas where little future development is expected, or where underground utility conflicts occur at the 30-inch depth.

424.4.1.5 A permanently marked warning tape to indicate the presence of traffic signal conduit shall be placed approximately 12" above the conduit in the backfill.

424.4.1.6 Conduit shall be terminated, stubbed, and capped when required, as shown on the plans or as directed by the ENGINEER. Metallic conduit ends shall be threaded and capped with standard conduit caps until wiring is started. Insulated metal ground bushings shall be provided for threaded ends when caps are removed, electrically connected per the requirements of the NEC. Nonmetallic conduit ends shall be capped until wiring is started.

424.4.1.7 Conduit terminating in pole, cabinet, or pedestal bases shall extend a minimum of 2 inches to a maximum of 4 inches vertically above the bases. Conduit entering a pull box shall terminate 1 inch to 3 inches inside the box wall and 2 inches to 3 inches above the top of gravel sump. Conduit entering through the bottom of a pull box shall be located near the sides and ends of the box so that the major portion of the box will be clear. Conduit shall enter from the direction of the run at all terminal points. Conduit shall enter boxes freely to allow for expansion and contraction. All metallic conduit terminations shall be installed with bushings to prevent wire insulation damage during its installation.

424.4.1.8 Conduit bends, except factory bends, shall have a radius not less than 6 times the inside diameter of the conduit. Where factory bends are not used, conduit shall be bent without crimping or flattening, using the longest radius practical. Metallic bends shall be used for difficult or long conduit runs to prevent damage to the conduit caused by pulling cables.

424.4.1.9 Conduit leading to walls, lights, or to fixtures below the grade of a pull box shall be sealed by a sealing conduit and an approved compound to prevent water from flowing into the fixture.

424.4.1.10 Existing underground metallic conduit to be incorporated into a new system shall be cleaned with a mandrel and blown out with compressed air. Existing nonmetallic conduit shall be blown out with compressed air. If excess amounts of foreign debris are encountered, conduit shall be flushed out with clean water and then air blown as directed by the ENGINEER.

424.4.2 NONMETALLIC CONDUIT

# 424.4.2.1 GENERAL

424.4.2.1.1 Nonmetallic conduit shall be straight cut, and ends shall be squared and trimmed after cutting to remove rough edges. Connections shall be of the solvent weld type except for connections to metallic conduit where the coupling shall be threaded on the metallic conduit side. Solvent weld connections shall be made according to the recommendations of the conduit manufacturer.

424.4.2.1.2 A bare No. 8 AWG copper conductor shall be run continuously in all nonmetallic conduit for bonding and grounding purposes. This bare conductor shall be installed in accordance with Section 426 -Wiring, and be considered incidental to the cost of the conduit. (Grounding conductors shall be based on National Electrical Code, Latest Edition. National Electrical Code shall determine the requirement).

424.4.2.2 BENDING: One of the following methods may be used to bend nonmetallic conduit:

424.4.2.2.1 An even heat, not to exceed 300 degrees F is applied to a portion of the conduit wrapped in aluminum foil until the desired flexibility is attained. Charring of the conduit shall be kept to a minimum.

424.4.2.2.2 The conduit is inserted into a 4-foot long water-filled steel pipe heated to the temperature required to render the conduit pliable after 30 seconds or longer. The conduit is removed from the hot water, bent as desired, and held in a jig for a cooling period of about 20 seconds.

424.4.2.2.3 The CONTRACTOR may use factory-made bends.

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424.4.2.2.4 Bending radii and number of bends shall comply with the applicable requirements of NEC and local codes.

424.4.2.3 EXPANSION COUPLINGS: Expansion couplings shall be installed according to the manufacturer's diagrams and instructions.

424.4.3 METALLIC CONDUIT.

424.4.3.1 GENERAL

424.4.3.1.1 Conduit ends shall be reamed to remove burrs and rough edges. Field cuts shall be true and square so that ends to be joined will butt together for the full circumference. Slip joints or running threads will not be permitted for coupling conduit. When a standard coupling cannot be used, an approved weatherproofed, threaded coupling shall be used. Non-threaded couplings shall be used only when approved by the ENGINEER.

424.4.3.1.2 Conduit threads shall be thoroughly painted with an approved rust-preventive paint before couplings are made up. Couplings shall be tightened until conduit ends are brought together and a good electrical connection is made throughout an entire conduit run. Conduit stubs, caps, exposed threads, and conduit surface areas damaged during handling or installation shall be painted with an approved bituminous or other paint suitable for the purpose.

# 424.4.3.2 WRAPPED GALVANIZED STEEL CONDUIT

424.4.3.2.1 Galvanized metallic conduit shall be wrapped for rust protection when required by the special provisions or the details shown on the plans. Rust protection shall be applied according to the following requirements:

424.4.3.2.1.1 Conduit surfaces shall be hand wire brushed to remove loose rust and scale, dust, and dirt. Oil and grease shall be removed with a suitable solvent. The surfaces to be coated shall be warmed with a torch to remove moisture.

424.4.3.2.1.2 An approved primer shall be brush-applied to the conduit surface before it has cooled. The protective coating shall not be applied until the primed surface has dried to a tacky consistency. 424.4.3.2.1.3 Tape shall be applied spirally to the conduit.

424.4.3.2.1.4 Galvanized metallic conduit with a PVC jacket coating of 0.025-inch minimum thickness may be furnished in lieu of wrapped galvanized steel. conduit Joints or couplings shall be painted with an approved bituminous paint and wrapped after installation with a minimum of 3 layers of pipe insulation tape of 0.010-inch minimum thickness and covered with mastic compound. Torn, cracked, or scuffed rust protection shall be repaired to the satisfaction of the ENGINEER as specified above. Repair material shall be applied to extend at least 6 inches on each side of the damaged area.

# 424.4.4 INSTALLATION UNDER EXISTING PAVEMENT

424.4.1 Metallic conduit shall be installed under existing pavement by approved jacking or drilling methods. Nonmetallic conduit shall not be installed by jacking. Nonmetallic conduit may be installed by drilling if a hole slightly larger than the conduit is pre-drilled and the conduit is hand-installed. Jacking or drilling pits shall be at least 2 feet from the edge of any type of pavement, measured from the side of the pit nearest to the pavement. Excessive use of water that might undermine pavement or soften subgrade will not be permitted.

424.4.4.2 The ENGINEER may approve relocation of conduit runs or pavement cutting when there is insufficient room for jacking or drilling pits or when underground obstacles are encountered.

# 424.4.5 CONDUIT FOR STRUCTURES AND FOUNDATIONS

424.4.5.1 GENERAL: An approved coupling as per this Section 424 shall be installed outside the concrete for future connections or removal on a metallic conduit run to a structure or foundation. Non-threaded couplings will not be accepted. If a pull box is located within 24 inches of a foundation, a coupling will not be required outside the foundation. Metallic conduit shall be rust-protected to a minimum of 6 inches inside a concrete structure or foundation. Rust protection will not be required for nonmetallic conduit.

424.4.5.2 BRIDGE STRUCTURES

424.4.5.2.1 Conduit in bridge structures shall be installed as shown on the plans. Conduit to be embedded

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in concrete for abutments, piers, or bridge decks shall be metallic. This conduit shall be securely attached to the reinforcing steel by approved methods at intervals not to exceed 4 feet. Conduit passing through abutment concrete shall be wrapped with 2 layers of 10-pound asphalt felt building paper, securely taped or wired in place. Conduit leading to soffits, walls, or light fixtures below the pull box shall be sealed by sealing said conduit or other light fixtures with an approved sealing compound. Conduit runs on structure surfaces shall be secured by galvanized malleable iron clamps spaced no more than 5 feet apart.

424.4.5.2.2 EXPANSION FITTINGS: Expansion fittings as detailed on the plans shall be installed where conduit crosses a structure joint. The tubing shall be the same size as the conduit. Expansion fittings shall have a bonding jumper of No. 6 AWG flexible wire or approved equal. Where the ENGINEER determines that expansion fittings or flexible tubing are not feasible, the conduit shall be installed in a watertight metal sleeve. The clearance between the outside of the conduit and the inside of the metal sleeve shall be <sup>1</sup>/<sub>2</sub> inch to 1 inch.

424.4.5.2.3 FLEXIBLE CONDUIT: Liquid-tight flexible conduit may be used between structure sections to accommodate for movement when called for on the plans. The liquid-tight flexible conduit shall be of an extruded polyvinyl jacket over a flexible hot-dipped galvanized core (Type UAG), UL listed and meeting NEC requirements. Liquid-tight flexible conduit may be installed within a concrete pour when approved by the ENGINEER.

424.5 MEASUREMENT AND PAYMENT.

424.5.1 Electrical conduit including expansion fittings and flexible conduits will be measured by the linear foot complete in place. Measurement will be made parallel to the center line of the installed conduit. Bends and sweeps will be considered incidental.

424.5.2 The accepted quantities of electrical conduit will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown on the bid proposal.

#### PULL BOXES, SPLICE CABINETS, AND MANHOLES

425.1 GENERAL: This work shall consist of furnishing and installing pull boxes, splice cabinets and traffic signal manholes in compliance with the specifications, the details shown on the plans, and Standard Drawings at the locations shown on the plans, or as established by the ENGINEER.

425.2 REFERENCES.

- 425.2.1 American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications, Latest Edition
- 425.2.2 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition
- 425.2.3 National Electrical Code (NEC), Latest Edition
- 425.2.4 National Electrical Manufacturers Association (NEMA) Standards, Latest Edition
- 425.2.5 This Publication, Latest Edition

SECTION 101 PORTLAND CEMENT CONCRETE SECTION 102 STEEL REINFORCEMENT

- SECTION 501 EXCAVATION AND BACKFILL FOR STRUCTURES
- SECTION 701 TRENCHING, EXCAVATION, AND BACKFILL
- 425.3 MATERIALS.

425.3.1 GENERAL

425.3.1.1 Electrical pull boxes shall be polymer mortar reinforced with heavy weave fiberglass unless otherwise approved or called for on the plans, and shall conform to the specifications and details in the plans. Electrical pull boxes are normally used in sidewalk, median and natural ground areas and shall have open bottoms installed with provisions for drainage. All electrical pull boxes shall be designed for light vehicular traffic, AASHTO H 10 loading (minimum).

425.3.1.2 Metal pull boxes shall be enclosed, watertight boxes to be installed in bridge decks and other areas only when specifically designated on the plans. All metal pull boxes shall be designed to support, in place, an AASHTO H 20 loading (minimum).

# 425.3.2 REINFORCED POLYMER MORTAR ELECTRICAL PULL BOX

425.3.2.1 Reinforced Polymer Mortar Electrical Pull Box. Pull box materials shall be an aggregate consisting of sand and gravel bound together with a polymer and reinforced with a heavy-weave fiberglass. The material shall have a minimum strength of 11,000 psi in compression, 1,700 psi in tension and 7,500 psi flexural strength.

425.3.2.2 The minimum acceptance criteria for material retention of 75% of control specimen values for load and deflection, no more than 2% change in weight or any dimension, no visual cracking, crazing, checking, blistering, or surface pitting. Changes in color will be permitted only if the change does not indicate degradation of material and will not be detrimental to the overall appearance of the product. In addition to the standard tests the material must have been tested at - 50°F and 140°F and have met the minimum criteria stated above.

425.3.2.3 The covers shall be made of heavy duty reinforced polymer mortar, unless otherwise shown on the plans, and shall be designed for a minimum for 15,000 pounds over a 10" square with a minimum test load 22,568. Covers shall be provided with flush lifting eye(s) and two openings for bolting the cover down.

# 425.3.3 METAL PULL BOX

425.3.3.1 Metal pull boxes shall be of external recess flanged, closed bottom type designed for flush mounting in concrete, conforming to the dimensions shown on the plans. All metal boxes shall be designed for vehicular traffic (AASHTO H20 loading), except installations in sidewalk areas where the plans specify a minimum of AASHTO H10 loading. All metal boxes shall be fabricated from cast iron with a hot-dipped galvanized finish.

425.3.3.2 Covers shall be of galvanized cross-ribbed cast iron or ductile iron, designed for the required loading. The covers shall be fastened to the boxes with stainless steel or brass screws, sealed with a neoprene gasket providing a water tight (NEMA 4) enclosure. The covers shall have a checkered (non-slip) surface with pry bar slots.

425.3.3.3 Conduit entrances may be made in the field

### PULL BOXES, SPLICE CABINETS, AND MANHOLES

by a hole saw or as approved by the ENGINEER.

425.3.4 COVER INSCRIPTION: Pull box covers shall be inscribed or embossed "DANGER ELECTRICAL" or "ELECTRICAL" as detailed on the plans. In addition, a bead weld or other type of permanent lettering approved by the ENGINEER shall follow this inscription to designate the specific circuit as follows:

HV - High Voltage Lighting (600 Volts or Greater) L - Low Voltage (Lighting and Rest Area Electrical)

- TS Traffic Signal
- SL Street Lighting

If a bead weld is used on a galvanized box the effected area shall be painted with a zinc-rich paint.

425.3.5 SPLICE CABINET

425.3.5.1 The CONTRACTOR shall furnish splice cabinets meeting NEMA 4x with steel back panel, hasp and staple for pad locking splice bar, and Type I standard. Fabrication of splice cabinets shall be as shown on the plans.

425.3.5.2 The splice cabinet shall be new, approximately 20"x30"x8" weather tight fabricated from 14 gauge steel or 0.125 inch minimum thickness aluminum. Splice cabinets shall be furnished with a low voltage splice bars having 50 units to the foot, six connectors per unit with each unit consisting of two (2) each, three-connector non-interconnected terminals, Bell Systems Part Number 66B33-50 or approved equal. The splice cabinet shall be mounted on a Type I standard on a pedestal foundation.

425.3.6 TRAFFIC SIGNAL MANHOLES: Traffic signal manhole, rings, covers, and concrete collars shall be the type, size, and material as shown on the Standard Drawings.

425.4 CONSTRUCTION REQUIREMENTS.

425.4.1 GENERAL

425.4.1.1 Each electrical pull box shall be installed so that the cover is flush with the curb or sidewalk grade and no part of the box or attaching screws protrudes above the surface. When no grade is established, covers shall be placed 1" higher than the surrounding ground to provide drainage away from the pull box. Metal pull boxes in

bridge decks and pavement shall be installed flush with the pavement surface.

425.4.1.2 Electrical pull box extensions shall be installed to provide additional volume as detailed on the plans and according to the details thereon.

425.4.1.3 The CONTRACTOR may install more pull boxes than shown on the plans to facilitate his work at his expense with approval from the ENGINEER.

425.4.2 SUMPS

425.4.2.1 With the exception of metal pull boxes installed in concrete, all pull boxes and traffic signal manholes shall have an 18-inch deep sump below the pull box or manhole. When pull box extensions are used with pull boxes to provide extra depth, sumps shall be 30 inches deep. The rock fill shall be 2-inch maximum size. Excavation for boxes shall be of sufficient width to allow a minimum 6-inch clearance on the sides of the boxes and extensions, with rock fill provided around outside walls.

425.4.2.2 Pull boxes shall be adequately supported by solid building blocks evenly spaced around the base. Thirty-pound felt paper shall be inserted between backfill and rock fill on vertical walls. Each pull box shall include a concrete collar.

425.5 MEASUREMENT AND PAYMENT.

425.5.1 Pull boxes, pull box extensions, traffic signal manholes, and splice cabinets will be measured by the unit complete in place.

425.5.2 The accepted quantities of pull boxes, pull box extensions, traffic signal manholes, and splice cabinets will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown on the bid proposal.

#### WIRING

426.1 GENERAL: This work shall consist of furnishing and installing wiring for traffic signal and highway lighting systems in compliance with the specifications, the details shown on the plans, and Standard Drawings at the locations shown on the plans, or as established by the ENGINEER.

#### 426.2 REFERENCES.

- 426.2.1 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition
- B3 Soft or Annealed Copper Wire
  B8 Concentric-Lay-Standard Copper Conditions, Hard, Medium-Hard, or Soft
- D2220 Poly (Vinyl Chloride) Insulation for Wire and Cable
- 426.2.2 International Municipal Signal Association (IMSA) Standards, Latest Edition
- 426.2.3 National Electrical Code (NEC), Latest Edition
- 426.2.4 National Electrical Manufacturers Association (NEMA) Standards, Latest Edition
- 426.2.5 Rural Electricification Administration (REA), Standard Specification, Latest Edition
- 426.2.6 Underwriters Laboratories Standards, Latest Edition
- 426.2.7 National Electrical Code (NEC), Latest Edition
- UL83 Thermoplastic-Insulated Wires

426.3 MATERIALS.

426.3.1 GENERAL: Wire and cable shall conform to the requirements of the appropriate sections of IMSA Wire and Cable Specifications and the National Electrical Code and shall carry the UL label. The specified trade size for conductors is copper. Only copper conductors of the trade size specified shall be furnished except as provided by the provisions of this Section 426.

#### 426.3.2 MULTI-CONDUCTOR

426.3.2.1 Multi-conductors shall be polyethylene insulated, poly vinyl chloride or polyethylene jacketed, solid wire signal cable complying with the requirements of IMSA Official Wire and Cable Specification 19-1 or 20-1. (Special multi-conductor cable for direct burial or selfsupporting applications shall be furnished conforming to the description and requirements on the plans.)

426.3.2.2 Conductor color coding shall be in accordance with IMSA Official Wire and Cable Specification 19-1 or 20-1 for unpaired conductor cables. Conductors shall be No.14 AWG size copper or as called for on the plans. Tracer color shall be molten dyed polyethylene co-extruded with the base color.

426.3.3 SINGLE CONDUCTOR

426.3.3.1 GENERAL: Single conductors shall be moisture and heat resistant thermoplastic-Insulated electrical cable rated at 600 volts for installation in conduit and pipe.

426.3.3.2 CONDUCTORS

426.3.3.2.1 All conductors and wiring sizing will be specified. The engineering evaluation and load base needs to comply with NEC standards.

426.3.3.2.2 When the substitution of aluminum for copper conductors requires a larger conduit size to meet NEC requirements than that specified, the larger size conduit shall be provided at no increase in cost to the Owner.

426.3.3.3 INSULATION

426.3.3.3.1 COMPOUND: Conductors shall be insulated with THHN or THWN thermoplastic complying with the requirements of UL-83 Standard for Thermoplastic-Insulated Wires.

426.3.3.3.2 THICKNESS: Thickness of insulation shall conform to the requirements of ASTM D 2220 and the National Electric Code.

426.3.3.3.3 TESTING: Conductor shall be factory tested to determine compliance to U-83 Standard for Thermoplastic-Insulated Wire.

426.3.3.3.4 IDENTIFICATION: Conductors shall have distinctive, permanent markings on the outer surface for the entire length showing manufacturer, type of insulation, size of conductor, and voltage rating. Insulation shall be solid color or of basic colors with a

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permanent colored stripe the entire length of the conductor in accordance with the specifications or as indicated on the plans or in the special provisions.

426.3.4 COMMUNICATION CABLE: Communication Cable shall be paired polyethylene insulated, polyethylene jacket communication cable with electrical shielding, rated 300 volts, suitable for use in underground conduit. All communication cable shall conform to REA specification PE-39. The conductors shall be solid No. 19 AWG unless otherwise specified on the plans.

426.4 CONSTRUCTION REQUIREMENTS.

426.4.1 GENERAL

426.4.1.1 Wiring shall conform to the appropriate requirements of the NEC and state and local requirements. Wiring within cabinets, pull boxes, and pole bases shall be neatly arranged and laced.

426.4.1.2 Powdered soapstone, talc, or other inert lubricant may be used for inserting conductors into conduit. Bushings shall be installed on all metallic conduit ends before pulling wire to prevent damage to the wire insulation.

426.4.1.3 Conductor splices will be permitted only inside of pull boxes, cabinets, and transformer bases with wiring access. Connections of wiring within standards shall be made at the appropriate terminals. No splicing of suspended cable used on span wire installations will be permitted.

426.4.1.4 For each conductor or cable, a minimum of 4 feet of slack shall be left at each signal or lighting standard and a minimum of 2 feet of slack shall be left at each pull box.

426.4.1.5 Ends of spare conductors shall be taped.

# 426.4.2 IDENTIFICATION

426.4.2.1 The phase or function of signal cable conductors shall be identified according to the insulation colors shown on the plans. Lighting circuit and signal service conductors shall be identified by black insulation. Two ungrounded multiple lighting conductors shall have black or red insulation. Neutral and common wiring shall have white insulation.

426.4.2.2 Identification tags shall be installed at cabinet, pull box, and pole locations where two or more conductors or cables for different functions have the same insulation colors. Permanent tags of fiber or PVC shall be used for tagging wires. 426.4.2.3 All low voltage circuits for pedestrian push buttons shall be separate from 115 volt function conductors in a separate multiconductor cable as identified at each splice point.

426.4.2.4 Communication cables shall be used for signal interconnect systems. Splicing shall be at splice cabinet or controller cabinet terminals or as shown on the plans. No other splicing shall be permitted.

426.4.3 TERMINALS: Cable wires shall be secured to screw-type terminals in traffic signal heads, pedestrian push buttons, and traffic controllers or as shown on the plans. Spade tongue type connectors shall be affixed to conductors using a tool specifically designed for connecting connectors to conductors.

#### 426.4.4 SPLICES

426.4.4.1 Soldered connections will not be permitted for splicing. Splices shall be wrapped with all-weather plastic electrical tape. The entire splice shall be weatherproof. When cables are pulled into conduit, the cable ends shall be taped to exclude moisture. The ends shall remain taped until splices are made or terminal appliances attached. One of the following types of connector shall be used for splicing 600-volt-maximum connectors:

426.4.4.1.1.1 Spring-Type Connector. The wire ends shall be joined with an insulated spring-type connector without soldering. A two-component, self-curing epoxy resin shall be furnished in a double compartment plastic envelope. The splice insulation shall be made by thoroughly mixing the two components in the envelope and, after cutting open one end of the envelope, inserting the wire connection into the epoxy resin and taping shut the open end of the envelope. Sufficient epoxy resin shall be provided to completely cover the connector and exposed bare wires at the connector.

#### 426.4.4.1.1.2

Single-component, 3M SCOTCHGUARD or approved equal splice insulation may be used in lieu of a twocomponent mixture. It shall be placed in accordance with the manufacturer's instructions.

426.4.4.1.2.1 Pin and Receptacle Locking-type Connector. The waterproof connector shall be capable of being disconnected without damage. The pin shall be of medium-hard copper material with the portion to be

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crimped on to the conductor fully annealed. The receptacle shall be of copper material fully annealed. The connector shall be of a size to provide not less than 90 percent ampacity of the conductor being spliced. The connector shall be applied to the conductor using a tool recommended by the connector manufacturer. Soldering will not be permitted. The pin and receptacle shall each have centrally located, recessed locking areas which shall match complementary areas of the housings.

426.4.4.1.2.2 The receptacle shall establish contact pressure with the pin through use of a copper beryllium sleeve spring. The receptacle and pin shall lock together so that the connection will be maintained when a 20-pound tension pull is applied to the attached conductors.

426.4.4.1.2.3 Separate housings shall be provided for the pin and receptacle. The housing shall be made of water-resisting synthetic rubber suitable for direct burial in the ground or installation where subject to direct sunlight. Each housing shall have an interior arrangement complementary to and suitable to receive and securely retain the applicable pin or receptacle. A water seal section shall be provided between the housings at the point of disconnection. A small slot or vent shall be provided along each housing to permit air exclusion. Silicon-type insulating compound sufficient to fill all voids in the assembly shall be placed in the housings before installation of the pin and receptacle.

# 426.4.5 FUSED SPLICE CONNECTOR

426.4.5.1 A fused disconnect splice connector shall be installed at each ungrounded conductor in Type V luminaire standard bases between the line and load sides on multiple lighting circuits. A similar unfused disconnect connector shall be installed between the load and line sides on the neutral when a neutral is used. Connectors shall be readily accessible from the standard base handhole. Required fused splice connectors shall be considered part of the wiring installation and no separate payment will be made therefor.

426.4.5.2 The splice connector shall enclose the fuse completely and shall be waterproof. The connector shall separate with the fuse held in the load side when the pole is dislodged. A receptacle-type design shall be used for the line side housing to maintain insulation between the line side electrode and surrounding ground planes. Fused splice connectors may be single or dual housings.

426.4.5.3 Splice connector terminals shall be rigidly crimped on to line and load connectors, using a tool recommended by the connector manufacturer. Terminals shall be insulated and made waterproof in accordance with the

connector manufacturer's recommendations.

426.4.5.4 Fuses shall be standard midget ferrule type. Fuses shall be sized to provide over current protection of the load per the NEC.

#### 426.4.6 BONDING AND GROUNDING

426.4.6.1 Metallic cable sheaths, metal conduit service equipment, 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 strip of at least the same cross sectional area as No. 8 AWG. Standards and pedestals shall be bonded by a bonding strip attached to the lower portion of the shaft or base.

426.4.6.2 For nonmetallic conduit systems, a bare copper wire of No. 8 AWG size or larger shall be run in and through all conduit runs, through all pull boxes, and to all poles. These wires shall be spliced at termination points and shall tie into neutral bars at service facilities or control cabinets to become true and functioning common bonds. In addition a ground rod may be installed at each pole or standard on a multiple lighting circuit when called for on the plans. Required ground rods shall be considered part of the wiring installation and no separate payment will be made therefor. Alternatively, provide nonmetallic conduit systems as established by the ENGINEER.

426.4.6.3 A ground rod (electrode) shall be installed at each multiple service point, each traffic signal standard, each cabinet foundation, and each luminaire foundation. Ground rods shall be hard drawn, high-conductivity electrolytic copper fluted rods or bare, round, hard-drawn copper covered steel rods. Ground rods shall be 3/4 inch nominal diameter 10 feet in length, installed as shown on details in the plans. Service equipment shall be bonded to the ground rod by a No. 6 AWG size copper wire enclosed in a ½-inch diameter rigid conduit. The portions of ground rods to be encased in concrete shall be wrapped with 3 layers of pipe insulation tape (0.01 inch min. thickness) or placed through one-inch diameter PVC conduit Or as established by the ENGINEER.

426.4.6.4 Metallic conduit in nonmetallic pull boxes shall be bonded by insulated grounding bushings and bonding jumpers. Metallic conduit in metal pull boxes shall be bonded by locknuts. (One locknut shall be used inside and one locknut shall be used outside of each box when the box is not threaded.)

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# 426.5 MEASUREMENT AND PAYMENT.

426.5.1 Wiring and cable will be measured by the linear foot complete in place.

426.4.2 The accepted quantities of wiring and cable will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown in the bid proposal.

#### SIGNAL ASSEMBLIES

427.1 GENERAL: This work shall consist of furnishing and installing traffic and pedestrian signal assemblies on signal poles and attaching back plates and directional louvers to traffic signals in compliance with the specifications, details shown on the plans, and Standard Drawings at the locations shown on the plans, or as established by the ENGINEER.

427.2 REFERENCES.

- 427.2.1 American National Standards Institute (ANSI) Standards, Latest Edition
- 427.2.2 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition
- B209 Aluminum and Aluminum-Alloy Sheet & Plate
- 427.2.3 Institute of Transportation Engineers (ITE) Publications, Latest Edition

Adjustable Face Vehicular Traffic Control Signal Heads

- 427.2.4 Manual on Uniform Traffic Control Devices (MUTCD), Latest Edition
- 427.2.5 National Electrical Code (NEC), Latest Edition
- 427.2.6 National Electrical Manufacturers Association (NEMA) Standards, Latest Edition
- 427.2.7 This Publication, Latest Edition
- 427.3 MATERIALS.

427.3.1 TRAFFIC SIGNAL ASSEMBLY

427.3.1.1 GENERAL

427.3.1.1.1 The number of signal faces (sections) in each traffic signal assembly will be shown on the plans. Signal faces shall be standard 12-inch lens size.

427.3.1.1.2 Signal assemblies shall meet the requirements of the latest edition of ITE Publication "Adjustable Face Vehicular Traffic Control Signal Heads," in addition to the requirements contained herein.

427.3.1.1.3 Signal assemblies shall be the adjustable, colored flat black, vertical or horizontal type with the number, color and type of lights (faces) shown on the plans and shall be adjustable through 360 degrees about the axis. Signal assemblies shall be mounted at the location and in the manner shown on the plans.

427.3.1.1.4 Signal assemblies shall be fabricated from polycarbonate resin material. The housing and door shall be fabricated from the same material. Polycarbonate resin material shall be flame resistant, ultra-violet stabilized, and shall withstand minimum of 70 foot-pounds of impact without fracture or permanent deformation.

427.3.1.1.5 All signal assemblies shall be designed so that back plates may be mounted.

427.3.1.2 OPTICAL UNITS

427.3.1.2.1 An optical unit shall consist of a lens, a reflector, and a lamp holder with lamp. The optical units shall conform to ITE Standards and ANSI Standards.

427.3.1.2.2 Lenses shall be of the color shown on the plans, circular, with a visible diameter of 12 inches. The design shall produce outward and downward light distribution, with a minimum of light distributed above the horizontal. Lenses shall be true color, and constructed of polycarbonate resin material, free from imperfections, and of high illumination transmission. The lens shall be capable of withstanding the heat associated with continuous illumination of 150 watt traffic signal lamp.

427.3.1.2.3 A reflector shall be one-piece alzak aluminum. An opening shall be provided in the back of each reflector for the lamp holder. This opening shall be designed so that there will be no dark spots cast on the lens.

427.3.1.2.4 Reflectors, lenses, and hoods shall be designed to reduce sun phantom to a minimum.

427.3.1.2.5 Lamp holders shall have a heat-resistant molded phenolic housing and be designed to accommodate a 150-watt standard A-21 traffic signal lamp. The holder shall be capable of positioning the lamp at the exact focal point of the reflector. The lamp holder shall provide proper lamp filament orientation without affecting lamp focus.

#### SIGNAL ASSEMBLIES

# 427.3.1.3 HOUSING

427.3.1.3.1 A signal housing shall consist of an assembly of separate sections without tie rods, substantially secured together in a watertight manner to form the number of units required and provide an acceptable appearance. Each section shall house an individual optical unit.

427.3.1.3.2 The housing of each section shall be a one-piece, polycarbonate resin material with sides, top, and bottom integrally molded. Polycarbonate housing shall be a minimum of 0.090 inch thick and ribbed to produce the strongest possible assembly consistent with light weight, and must pass ITE wind load testing.

427.3.1.3.3 Each section shall include a one-piece hinged door, with mounting for the lens, and other parts of the optical system, watertight gaskets, and a simple non-corrosive door locking device. The optical system shall be mounted so that the various parts may be readily accessible or removable. Sections shall be interchangeable and constructed so that they can be removed or added. A round opening shall be provided in the top and bottom of each head to receive a 1½-inch supporting pipe frame.

427.3.1.3.4 Each door shall be hinged and held securely to the body of the housing by two stainless steel hinge pins, eye bolt, washer and wing nut. Exposed screws and fasteners shall be non-corrosive. Interior screws and fasteners shall be fabricated from corrosion-resistant nonferrous materials.

427.3.1.3.5 A locking boss with 72 teeth shall be integrally cast or molded into the signal housing at both openings. The angle of the teeth shall be 90 degrees, and the depth of the teeth shall be 3/64 inch. The locking boss, when used with other locking fittings of the same mesh or with or without use of an adaptor, shall provide positive positioning of the entire signal head to eliminate rotation or misalignment.

427.3.1.3.6 The reflector and lamp holder shall be held in place by an aluminum reflector ring, pivoting so that it is independent of the door. The unit shall be designed so that the lamp may be replaced without the use of tools.

427.3.1.3.7 Weather-resistant neoprene gasketing shall be provided so that the inside of the lens and reflector are sealed from dust and moisture.

427.3.1.3.8 A terminal block shall be mounted in the back of the middle section of the signal assembly. The terminal block for all signal assemblies shall be a 4-position, 8-terminal, barrier-type strip at a minimum. The signal section leads shall be attached to the left of each terminal block. The opposite terminals shall be for the field wires.

427.3.1.3.9 Wiring from each lamp holder shall be provided by two-coded leads with NEMA quick disconnect tabs. A white wire shall be connected to the shell of the lamp holder. A black or colored wire shall be connected to the bottom or end terminal of the lamp holder. For identification, color coded leads shall be colored the appropriate red, yellow, or green, (yellow or green tracer for arrow indications), or, if black wires are used, the terminals to which the leads are attached shall be permanently marked as to the indication. Leads shall be No. 18 AWG size, Type TFF.

427.3.1.4 VISORS: A 12-inch nominal long tunnel visor shall be provided for each signal section. Visors shall be fabricated from polycarbonate resin material. Tunnel visors shall encircle the lens for 300 degrees with a four (4) inch open slot on the bottom. The visor shall have four (4) twist-on attaching ears for installation to the signal door by four (4) non-corrosive screws. The vertical outer face of the door shall have four threaded holes equally spaced about the circumference of the lens opening and 45 degrees from the horizontal or vertical axises so as to permit a vertical or horizontal installation of the signal assembly.

# 427.3.1.5 FRAMEWORK OR MOUNTING BRACKETS

427.3.1.5.1 Mounting brackets shall consist of assemblies of 1<sup>1</sup>/<sub>2</sub>-inch nominal size standard steel pipe and malleable iron, ductile iron, or brass pipe fittings. Securely assembled members shall provide plumb or level support.

427.3.1.5.2 Conductors shall be concealed within framework, poles, and signal assemblies. Conductors entering assemblies from poles shall be supported and protected by cable guides. Threads shall be coated with grease during field assembly.

427.3.1.6 FINISH: The finish color for all signal assembly components shall be flat black. The flat black color shall be completely impregnated in the resin

#### SIGNAL ASSEMBLIES

material, and scratches shall not expose uncolored material.

# 427.3.2 OPTICALLY PROGRAMED SIGNAL ASSEMBLY

427.3.2.1 Optically programmed traffic signal assemblies will be used instead of standard traffic signal assemblies at locations shown on the plans where it is necessary to limit the visibility zone of the indication. Optically programmed assemblies shall have the same general appearance and shall be mounted in the same manner as the standard assemblies shown on the plans and specified in this Section 427 except that lens faces shall appear square when not illuminated. The object lens shall provide a round signal indication when illuminated. Sufficient optical masking tape shall be supplied with each assembly to allow proper aiming of each section. Aiming of signal sections shall be done under the Traffic Engineer's supervision.

427.3.2.2 Optically programmed signal assemblies shall conform to the requirements for traffic signal assemblies, except as follows:

427.3.2.2.1 Optically programmed assemblies shall permit the visibility zone of the indication to be determined optically and shall require no hoods or louvers. The projected signal may be visible or selectively veiled anywhere within 15 degrees of the optical axis. No indication shall result from external illumination nor shall one indication illuminate a second indication.

427.3.2.2. The components of the optical system shall consist of a lamp, a circulet reflector, an optical limiter-diffuser, and an objective lens. The lamp shall be mated to the diffusing element by a circulet reflector with a specular inner surface. The optical limiter-diffuser shall be composed of heat resistant glass. The limiter-diffuser shall provide an imaging surface, at focus on the optical axis for objects 900 feet to 1200 feet distance, and shall permit an effective veiling system to be variously applied as determined by the desired visibility zone. The limiter-diffuser shall have a positive means of indexing.

427.3.2.2.3 The objective lens shall be a high resolution planar incremental lens hermetically sealed with a flat laminate of weather resistant acrylic.

427.3.2.2.4 Visors shall be 9<sup>1</sup>/<sub>2</sub> inch-long cutaway type, finished in flat black.

427.3.2.2.5 The lens shall be symmetrical in outline and shall be capable of being rotated to any 0-degree orientation about the optical axis.

427.3.2.2.6 Exteriors of the signal case, lamp housing, and mounting flanges shall be finished in accordance to this Section 427.

427.3.2.2.7 Lamp fixtures shall consist of a separately accessible housing and integral lamp support, a ceramic socket, and self-aligning, quick-release lamp retainer. The electrical connection between case and lamp holder shall be an interlock assembly which disconnects the lamp holder when open. Coded No. 16 AWG size lead wires of a length sufficient to permit solderless connection to line wires external to the signal shall be used.

427.3.2.2.8 The assembly shall mount to standard 1<sup>1</sup>/<sub>2</sub>inch fittings as a signal section or a multiple section face or in combination with other signals. A rigid connection shall be provided that will permit the signal section to tilt from at least 9 degrees above to 9 degrees below the horizontal while maintaining a common vertical line through couplers and conduit. The assembly shall be mountable with ordinary tools and shall be serviceable without tools.

427.3.3 PEDESTRIAN SIGNAL

427.3.3.1 GENERAL: Pedestrian signals shall be one-way signals in weatherproof vandal resistant and dust-tight housing, designed to display the alternating symbol messages "HAND" in Portland Orange or "WALKING PERSON" in Lunar White. The assemblies shall be neon.

427.3.3.2 PEDESTRIAN SIGNAL - NEON

427.3.3.2.1 GENERAL

427.3.3.2.1.1 The signal shall be a one section signal assembly with symbols "HAND" and "WALKING PERSON," capable of displaying the alternate messages and conforming to the details in the plans and to the MUTCD.

427.3.3.2.1.2 The signal shall be internally illuminated. The message shall be formed by painting (blankout) the message plate except for the area occupied by the 11-inch high and 6-inch minimum wide symbols.
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427.3.3.2.1.3 The messages shall blank out when not energized.

427.3.3.2.2 HOUSING

427.3.3.2.2.1 The housing shall be a one-piece corrosion- resistant aluminum alloy casting with integrally cast top, bottom, sides, and back. An opening shall be provided in the top and bottom of the housing to accommodate standard 1 ½-inch pipe brackets. A shurlock boss shall be integrally cast into the housing at the bottom opening. Four integrally cast hinge lug pairs, top and bottom, shall be provided for the door mounting.

427.3.3.2.2.2 The housing door shall be a one-piece corrosion-resistant aluminum alloy casting with integrally cast hinges. The door shall be attached to the housing by stainless steel spring pins. The door shall pivot or swing downward when opened. A gasket shall be provided between the door and the housing. Latching shall be by two noncorrosive hinged bolts with captive wing nuts and washers.

427.3.3.2.2.3 The complete housing (assembly) shall be 18 to 19 inches wide, 18 to 19 inches high and 9 to 10 inches deep with the visor.

427.3.3.2.3 MESSAGE MODULE

427.3.3.2.3.1 A message module shall consist of neon tubes, a molded, white, acrylonitrile butadine styrene or polycarbonate plastic tubing housing, and a screened message lens. The message lens shall be an integral assembly with the tubing housing, fitted with a neoprene gasket around its perimeter.

427.3.3.2.3.2 Two compartments shall be formed in the front of the module, enclosing and protecting the two neon tube light sources. The material may be white or the inside of the tubing compartments shall be painted with white acrylic paint to provide a protective background.

427.3.3.2.3.3 The tubing for the "HAND" symbol shall be a minimum of 10 mm diameter and shall be coated on the inside with fluorescent material producing the desired Portland Orange output. Tubing for the "WALKING PERSON" symbol shall be a minimum of 9 mm and coated on the inside for the desired Lunar White output.

427.3.3.2.3.4 The tubing housing shall hold neon tubing in a positive location relative to the message plate so that

a clearly readable message is provided. The tubing housing shall require no tools for removal or replacement.

427.3.3.2.3.5 The tubing housing shall be provided with electrical contracts which will plug directly into recessed contacts or connect to flexible high tension leads by snap-on connectors. To reduce corona effects, flexible leads shall be of the minimum length necessary to allow the door to swing open.

#### 427.3.3.2.4 MESSAGE LENS

427.3.3.2.4.1 The message lens shall be one of the following:

427.3.3.2.4.1.1 Ultraviolet stabilized polycarbonate plastic with external prismatic pattern, 1/8-inch minimum thickness.

427.3.3.2.4.1.2 Ultraviolet stabilized acrylic plastic with prismatic pattern, 3/16-inch minimum thickness.

427.3.3.2.4.2 For both types, the first coating of blankout paint shall be black and the second coating shall be white to reflect internal light.

#### 427.3.3.2.5 TRANSFORMERS

427.3.3.2.5.1 Solid state circuitry shall be assembled on one or two printed circuit boards, energizing two high voltage flyback transformers for the respective neon tubes. The transformers and circuitry shall be in an enclosure behind the tube compartments providing protection from water penetration and physical damage.

427.3.3.2.5.2 The "Hand" and "Walking Person" circuits shall require approximately 30 watts with a voltage range of 105 to 130 V.A.C. Each circuit shall be internally fused. Quick disconnect lugs shall be provided inside the housing for easy removal. A three-terminal pair (6-position) screw type terminal block shall be provided for termination of field wires.

427.3.3.2.6 SCREENS

427.3.3.2.6.1 One of the following types of screens (visor) shall be provided for each signal:

427.3.3.2.6.1.1.1 Z crate type screen shall consist of a minimum of 20 straight horizontal louvers and 21 horizontal louvers formed in a zig zag pattern. Every other formed louver shall be reversed so as to form cells 1 inch square, rotated 45 degrees from the horizontal

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(diamond shaped cells). Each diamond shall then be bisected by insertion of a straight louver interspersed between each pair of formed zig zag louvers. Where each apex of each formed louver contacts a straight louver, the entire length of the joint shall be chemically welded.

427.3.3.2.6.1.1.2 The material shall be nominally 0.030 inch thick, black polycarbonate plastic with a flat finish on both sides. The screen shall be enclosed in a 0.040 inch minimum thickness aluminum or polycarbonate plastic frame. The frame shall be  $1\frac{1}{2}$  inches deep and contain mounting holes for insertion in the door frame.

427.3.3.2.6.1.2.1 Eggcrate type screen, 1½ inch deep, of 0.020 inch minimum thickness aluminum of 3003 H14 alloy conforming to the requirements of ASTM B 209 or polycarbonate of 0.036-inch nominal thickness. The assembly shall be mounted on an aluminum alloy or polycarbonate frame of 0.040-inch minimum thickness.

427.3.3.2.6.1.2.2 The spacing between horizontal members shall be  $\frac{1}{2}$  inch (beginning near the top of the symbol) and supported by a minimum of 15 vertical members.

427.3.3.2.7 FINISH: The inside and outside surfaces of the housing, doors, and visor screens shall be finished in a factory applied, environmentally safe, electrostatically applied, ultra violet resistant powder coating of the color flat black, which will then be ovencured. Pretreatment of all exposed metal parts excluding stainless steel attachment hardware shall utilize current industry standards of multi-stage pretreatment.

427.3.3.2.8 All exposed screws and fasteners shall be of ANSI Type 304 stainless steel. Interior screws shall be made of noncorrosive materials or be cadmium plated.

427.3.4 BACKPLATES: Backplates shall be provided for signal faces with vehicular signal indications when shown on the plans. Backplates shall be one (1) piece polycarbonate and shall be of a size to provide a 5-inch border around the perimeter of the signal. Backplates shall be finished in accordance with the requirements of this Section 427.

427.3.5 DIRECTIONAL LOUVERS: Directional louvers shall be installed in signal visors at locations shown on the plans. Louvers shall be sheet aluminum and shall be made to fit snugly in the signal visors. Louvers shall be 11-3/8 inches in diameter and 8½ inches long and

shall have a degree of cutoff from either side of the center axis of the light beam of  $10\frac{1}{2}$  degrees. Louvers shall be finished in accordance with the requirements of this Section 427.

## 427.3.6 TRAFFIC SIGNAL LAMPS

427.3.6.1 All incandescent lamps for signal assemblies shall be clear, ANSI designation A21, horizontal with medium base, 8000-hour rated life traffic signal lamps. All 12-inch signal assemblies shall be furnished 150-watt, 1770 average minimum initial lumens lamps.

427.3.6.2 Each lamp socket and lamp furnished shall be designed to position the lamp filament accurately within the reflector. (Light center length: 150-watt--3 inches.)

## 427.4 CONSTRUCTION METHODS.

427.4.1 Vehicular signal assembly faces shall be covered after installation until the controller and intersection signals are placed into operation. The covering shall be such so as not to permit any misunderstanding by the general public that the signal may be in operation.

427.4.2 Signal faces shall be plumb and adjusted to proper direction. Faces and frameworks shall be plumb and level, symmetrically arranged, and secure after alignment. Mounting shall conform to details in the plans.

427.4.3 Overhead mast arm mounted traffic signal assemblies will normally be mounted horizontally. When the plans call for an overhead signal assembly to be mounted vertically to a mast arm or span wire, the mounting bracket shall be as detailed in the plans.

427.4.4 Backplates and directional louvers shall be installed on signal assemblies according to the recommendation of the manufacturer.

# 427.5 MEASUREMENT AND PAYMENT.

427.5.1 Traffic signal assemblies, optically programmed traffic signal assemblies, backplates, and directional louvers will be measured by the unit complete in place.

427.5.2 The accepted quantities of traffic signal assemblies, optically programmed traffic signal

# SIGNAL ASSEMBLIES

assemblies, backplates, and directional louvers will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown on the bid proposal.

# VEHICLE, PEDESTRIAN, AND EMERGENCY VEHICLE DETECTORS

428.1 GENERAL: This work shall consist of furnishing and installing vehicle detectors in roadways, pedestrian push buttons on signal standards, and emergency vehicle optical detectors (EVOD) systems at signalized intersections in compliance with the specifications, details shown on the plans, and Standard Drawings, at the locations shown on the plans, or as established by the ENGINEER.

428.2 REFERENCES.

- 428.2.1 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition
- D49 Chemical Analysis of Red Lead
- D113 Ductility of Bituminous Materials
- D150 AC Loss Characteristics
- D412 Rubber Properties in Tension
- D903 Peal or Striping Strength of Adhesive Bonds
- D1190 Concrete Joint Sealer-Hot Poured Elastic Type
- D2240 Rubber Property-Durometer Hardness
- 428.2.2 International Municipal Signal Association (IMSA) Standards, Latest Edition

Official Wire and Cable Specifications

- 428.2.3 Manual On Uniform Traffic Control Devices (MUTCD), Latest Edition
- 428.2.4 National Electrical Code (NEC)
- 428.2.5 National Electrical Manufacturers Association (NEMA) Standards, Latest Edition
- 428.3 MATERIALS.

428.3.1 LOOP VEHICLE DETECTOR MODULE

428.3.1.1 GENERAL.

428.3.1.1.1 A loop vehicle detector module shall be a self contained, electronic sensing device which registers the presence of a vehicle by recognizing inductance change in a loop of wire embedded in a roadway. The detector module shall be rack mounted in a traffic signal controller cabinet, connected to the cabinet wiring through 44 terminal cinch jones connector (50-44-30m) and wire harnesses. All detector modules shall be the two channel type with independent channel controls. When

called for on the plans, each channel shall include a delay/extension time function.

428.3.1.1.2 All loop vehicle detector modules shall in combination with this specification conform to NEMA Standards Publication TS-1-1989 or latest edition for Traffic Control Systems.

428.3.1.2 DESIGN

428.3.1.2.1 All loop detector modules shall utilize digital design throughout (for threshold, time and cycle calculations). Period measurement, the time elapsed per cycle, or frequency measurement, the cycles counted in a set time interval, may be used as a means to determine a change in inductance.

428.3.1.2.2 The two channel construction shall insure isolation of the channels, to allow elimination of "cross talk" between adjacent loops by frequency selection. Period measurement detectors shall use alternate scanning to accomplish this isolation. Isolation may also be accomplished by sequential excitation and measurement.

428.3.1.2.3 The detector module shall include a fail safe to call feature on each channel to provide a detect output in the event of open circuit loops.

428.3.1.2.4 The minimum composite loop inductive operating range shall be 50-1000 micro-henries and shall allow up to 1000 feet of loop lead-in.

428.3.1.2.5 Detector modules may be self-tuning with a utomatic tracking or require initial tuning with a minimum automatic drift compensation range of  $\pm 5$  percent after initial adjustment

428.3.1.2.6 Detector module outputs should be optically coupled. The output shall be fail safe (closed) in the event of power loss.

428.3.1.3 OPERATION

428.3.1.3.1 Operational selections or adjustments shall be made by digital or thumb wheel switches on the front panel. A minimum selection of three frequency ranges and three sensitivity (change in inductance) ranges shall be provided along with a presence or pulse output mode and a reset selector. Controls shall be separate and repeated for each channel.

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428.3.1.3.2 An output indication (LED) shall be provided for each channel and located on the front panel.

428.3.1.4 DELAY / EXTEND OPERATION

428.3.1.4.1 When specified on the plans, each channel shall include a digital timer to permit delaying or extending detection outputs.

428.3.1.4.2 Loop vehicle detectors shall include switches to select delay, extend/delay time, extension or timer off operation. Minimum range and steps shall be 0-30 seconds in 1-second increments for delay time and 0-7.5 seconds in 0.5-second increments for extend time.

428.3.1.4.3 Output indicators shall display difference in normal detection and delay/extend interval by flashing during this period or by two indicators per channel, separating "Call" and "detect."

428.3.1.4.4 An external input for each channel shall be provided for the state of the green indication of the associated phase. When this "green" input is true, it shall disable delay timing, and when false, extension timing shall be disabled. (When detector logic inhibits times only on application of external signal (115 VAC), connect external input to same phase red when plans call for extend operation.)

428.3.1.5 TWO CHANNEL DETECTOR: On a two (2) channel detector, both channels shall have active power inputs so as to permit either channel to be operated independently without the remaining channel connected. All connector terminal assignments shall comply with NEMA Standards Part 15.

428.3.1.6 LIGHTNING AND TRANSIENT PROTECTION: All detectors shall meet the NEMA requirements for transient testing. This shall be accomplished through the use of MOV(s) for protection from voltage induced in loop lead, installed in cabinet at loop field terminals; flash over protection from internal circuit to ground.

## 428.3.1.7 TESTING

428.3.1.7.1 The CONTRACTOR shall have the loop vehicle detectors for testing prior to the ENGINEER's acceptance of compliance with these specifications. Said testing will be effected concurrently with the controller

testing under Section 429 - Traffic Actuated Controllers.

428.3.1.7.2 The loop vehicle detectors will be inspected and tested as follows:

428.3.1.7.2.1 Visual inspection for compliance with the specifications and requirements on the plans.

428.3.1.7.2.2 Sample testing for compliance to NEMA standards.

428.3.1.7.2.3 Testing of the completed loop detector installations in accordance to the following. A small vehicle will be simulated by two empty standard steel five-gallon pails each, approximately 12 inches diameter by 19 inches deep and weighing 3.5 pounds held 12 inches over the pavement (SVS--small vehicle simulation).

428.3.1.7.2.3.1 SENSITIVITY TEST: Using four 6-foot by 6-foot, 3-turn loops in series, 100 feet of lead-in cable, hold one pail over center of a loop, then two pails. The detector shall detect at a maximum height of 12 inches and 30 inches, respectively, over the pavement. Repeat using 500 feet of lead-in cable. Using 6-foot by 30-foot, 2-turn (2-4-2) quadruple loop with 100 feet of lead-in cable, carry two pails (SVS) transversely across loop. The detector shall detect and hold the entire distance across the loop at a maximum height of 12 inches. Repeat with 500 feet of lead-in cable. (Actual installation sensitivity tests may be made with the lead-in cable required on the plans, up to 1000 feet and total loop areas not exceeding the special test loops.)

428.3.1.7.2.3.2 HOLD TIME TEST: Under the sensitivity test procedure, an SVS held over the center of each type loop shall provide a continuous detection output for at least 3 <sup>1</sup>/<sub>2</sub> minutes.

# 428.3.1.7.2.3.3 LONG DETECTION AND RECOVERY TEST

428.3.1.7.2.3.3.1 Using a single 6 foot by 6 foot loop or a 6 foot by 30 foot quadruple loop, with sensitivity set for a small vehicle park automobile over loop. The detector shall be capable of holding call for 10 minutes.

428.3.1.7.2.3.3.2 After the automobile is tuned out, remove the automobile and immediately repeat hold time test. The detection shall be dropped and then immediately picked up and held by an SVS.

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428.3.1.7.2.3.4 ADJACENT LANE REDUCTION TEST: Using the lowest sensitivity setting that produces detection under the sensitivity test, park an automobile 3 feet from nearest edge of loop(s) and repeat sensitivity test.

428.3.1.7.2.3.5 PULSE MODE REPHASE TEST: Using the detector in pulse mode, park an automobile transversely across the loop(s). Two seconds after the automobile is parked the remainder of the loop shall detect an SVS (generate additional output pulse). Remove the automobile and verify that within one second an SVS is detected.

428.3.1.7.2.3.6 Loop detectors shall perform satisfactorily for the 30-day test period in accordance with the requirements on the plans.

428.3.2 LOOP DETECTOR WIRE (Field)

428.3.2.1 LOOP DETECTOR WIRE: Loop detector wire shall be used for installation in pavement saw cuts. All loop detector wire shall be No. 14 AWG stranded copper wire cross-linked polyethylene (XHHW) insulation conforming to requirements of IMSA Official Wire and Cable Specification 51-3.

428.3.2.2 DUCTED LOOP DETECTOR WIRE: Ducted loop detector wire shall be used for installation in pavement saw cuts or by directly overlaying with paving material. Ducted loop detector wire shall be loop detector wire loosely encased in a polyvinyl chloride or a polyethylene, 0.250 inch O.D. tube. All ducted loop detector wire shall conform to the requirements of IMSA Official Wire and Cable Specification 51-5, except the interior No. 14 AWG stranded conductor may either be insulated with polyvinyl chloride with a nylon jacket (THHN) or polyethylene (XHHW).

428.3.3 LOOP LEAD-IN CABLE: Loop lead-in cable shall be used to connect the loop (installed in the pavement) to the loop detector unit (installed in controller cabinet). Loop lead-in cable shall be No. 16 AWG copper, polyethylene insulated twisted pairs, shielded and enclosed with a polyethylene jacket. All loop lead-in cable shall conform to IMSA Official Wire and Cable Specification 50-2.

# 428.3.4 LOOP DETECTOR SEALANT

428.3.4.1 Loop detector sealant shall be used as a filler for loop saw cuts, and to secure and protect the loop detector wire. The sealant shall have sufficient strength and hardness to withstand the stress and abrasion subjected by vehicular traffic yet remain flexible enough to provide stress relief under thermal movement. The sealant shall have the ability to bond to both concrete and asphalt, a rapid rate of curing (open to traffic in ½ hour after installation), initial fluidity to permit installation in a narrow saw cut to at least 40 $\Box$ F, moisture insensitivity (apply to damp pavement), and resistance to vehicular fluids and road salt.

428.3.4.1.1 HOT-TYPE APPLICATION: Sealant shall be a hot-melt, rubberized asphalt compound furnished in "bricks" which is formulated specifically to be stiff, non-tracking, flexible at low pavement temperatures, and suited for use as a sealant for traffic loop cuts. At application temperatures, sealant shall be a thin, free flowing fluid which pours easily, penetrates fine cuts, self-levels, and permits easy application. Sealant shall be melted and applied to pavements in accordance with manufacturer's recommendations using either pressure feed melter applicator units or pour pots. After curing, the sealant shall have the following minimum physical and electrical properties:

<u>TEST</u>	ASTM METHOD	MIN.
Penetration, 77 <sup>0</sup> F,	D 1190	35 max.
(100 g, 5 sec) Softening Point		180 <sup>0</sup> F min
Ductility, 77 <sup>°</sup> F	D 113	15 cm min.
Mandrel Bend, <sup>0</sup> F,		
180 deg., 5s, ½" dia.	Pass	
Pour Temperature	380 <sup>o</sup> F	
Safe Heating Temperatu	re As specified	

428.3.4.1.2 COLD-TYPE APPLICATION.

428.3.4.1.2.1 Sealant shall be furnished in quart cartridges or 5-gallon pails, and may be applied by conventional cartridge gun or bulk handling pump equipment. The uncured (wet) material shall have a viscosity of 20,000 cps (approximately) at 77°F using a Brook-field Viscometer, #6 spindle at 20 RPM, and have a nonvolatile content (solids) of 75-85% by weight. The material shall cure at a rate to allow, being driven over almost immediately after installation and be dry to the touch within 24 hours. The sealant shall be nonshrinking

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and remain flexible at temperatures down to  $-40\Box$ F. Sealants shall have the following minimum physical and electrical properties after curing:

<u>TEST</u>	ASTM METHO	<u>D</u> <u>MIN.</u>
Hardness	D 2240	65-85
Tensile Strength	D 412	500 psi
Elongation	D 412	400%
Adhesion (Peel Stren	ngth) D 903	15 lb.
(canvas to conc.)		
Arc Resistance	D 49	71 secs
Dielectric Strength	D 150	6.35 @ 50 Hz

428.3.4.1.2.2 The CONTRACTOR shall include, with material submittal lists, manufacturer's test data for listed physical properties, and installation recommendations. When requested by the ENGINEER, the CONTRACTOR shall also furnish a sample for evaluation by the ENGINEER. Sealant formulas judged to have failed within one year (either test or permanent installation) shall not be acceptable. Failure shall be considered excessive shrinkage, cracking, peeling and/or bond failures to pavement.

#### 428.3.5 PUSH-BUTTON STATION

428.3.5.1 The housing of the push-button station shall be of substantial tamper proof construction and made of cast aluminum. The assembly shall be weatherproof and so constructed that it will be impossible to receive any electrical shock under any weather conditions. The housing shall be shaped to fit the curvature of the pole to which it is attached and shall provide a rigid installation. The housing body shall contain a direct push-type actuator button, micro-switch-type or approved equal. The housing cover shall be of the same size and shall contain the push-button sign.

428.3.5.2 Pedestrian push-button signs shall be porcelain enameled sheet steel of 0.036-inch minimum thickness or sheet aluminum of 0.063-inch minimum thickness; 9 inches by 12 inches in size. Each hole shall be provided with a brass grommet if porcelain enameled steel signs are used. Sign corners shall be finished round. Instructions and arrows on the signs shall be black enamel on white enamel background, and the instructions shall be as shown on the plans.

428.3.5.3 Push button housings shall be finished with two coats of best quality infrared oven-baked paint as

follows:

428.3.5.3.1 FIRST COAT: Baked epon primer, zinc chromate or equal.

428.3.5.3.2 SECOND COAT: Flat black baked enamel.

428.3.5.4 A single piece cast aluminum pedestrian push-button assembly composed of a push-button assembly, pedestrian sign, sign frame and mounting saddle shall be used when shown on the plans. The pushbutton shall have silver contacts rated at 35 amps at 12 volts and shall be constructed in such a fashion to prevent vandalism and freezing in inclement weather. The casting shall include a raised legend suitable for visually impaired pedestrians. The single piece pedestrian push-button assembly shall be capable of being attached either by drilling and tapping the mounting surface or by using banding brackets as shown on the plans.

#### 428.3.6 PREFORMED DETECTOR LOOPS.

428.3.6.1 Preformed detector loops shall be factory assembled and shall be asphalt-rubber filled predimensioned loop detectors. The loop shall consist of two or more turns of No. 14 wire with type TFFN insulation. The loop detector wire shall be encased in 3/8 inch polypropylene conduit in the head of the loop. The conduit shall be injected with hot rubber-asphalt sealant to prevent the entrance of water and the movement of wires within the conduit. Inter-loop splicing will not be permitted, but fold points may be provided to facilitate shipping, handling, and installation. Fold points shall occur at not less than six (6) feet nor more than every twenty (20) feet.

428.3.6.2 Conduit used for the loop assembly shall be polypropylene 3/8 inch Copolymer PP SDR-9 molded to the shape required. Typical corner radius on quadruple, diamond, and square shaped loops shall be three (3) inches. The corners shall be hot molded 90 degree bends which are all integral to the loop conduit.

428.3.6.3 Joints shall be located for convenience in shipping and installation. A nominal five (5) inch space shall be provided in the 3/8 inch polypropylene. A sleeve that slides over the space in the 3/8 inch polypropylene shall be a ten (10) inch length of 3/4 inch polypropylene schedule 80.

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428.3.6.4 Expansion-contraction joints shall be used at all fold points as specified herein.

428.3.6.5 A Tee shall be used at the center connection on quadrapole shape loops. All Tees shall be CPVC heavy wall injection molded.

428.3.6.6 A flexible ½ inch schedule 80 PVC section shall be used to connect the pull Tees to the body of the loop assembly and to the home-run or interconnect. The length of the flexible section shall be as required for proper assembly and to maximize the physical strength of the loop. The flexible Tee section shall have a nonmetallic cover made with CPVC and extended skirts with ribbed re-enforcing. It shall be made with heavy wall CPVC and have the strength required to withstand construction equipment loading.

428.3.6.7 The side outlets of the Tee body shall be one (1) inch deep and joint with ½ inch trade size PVC or CPVC conduit. The center outlet of the Tee shall accept a 3/4 inch trade size conduit. The cover shall be glued onto the Tee body upon completion of the assembly.

428.3.6.8 The completely assembled Tee shall be able to withstand the weight of fully loaded dump and concrete trucks, the tracks of paving machines, and similar construction vehicles and equipment. It shall not break, crack, or crush when subjected to compressive loading of heavy construction equipment.

428.3.6.9 The field installation of the preformed detector loops shall consist of the routing and placement in existing asphalt pavement during applications of hot asphalt, or prior to concrete paving.

428.3.6.10 All material for assembling and installing the interconnects and home-runs shall be provided directly by the manufacturer. Field assembly of the home-runs and interconnects may result in the conduits being partially sealed when approved by the ENGINEER.

428.3.6.11 The use of factory-sealed home-runs and interconnects shall be used wherever possible.

428.3.6.12 Loop detector, home-runs, and interconnections layouts shall be as recommended by the manufacturer, but shall achieve the traffic lane or movement detection as indicated on the plans and as specified herein. 428.3.6.13 The pull boxes and terminal hand holes shall be installed when called for on the plans, but can be field adjusted for the installation of the home-runs and interconnections for the performed detector loops. However, the field adjustments will require the pull boxes and terminal hand holes to be installed in preformed detector loops. The manufacturer's field positions of the pull boxes and terminal hand holes shall be approved by the ENGINEER.

#### 428.3.7 Microloops

428.3.7.1 Microloops shall be a small, cylindrical unit designed to be installed beneath the road surface which shall be capable of being connected to an inductive loop vehicle detector to provide pulse mode vehicle detection. Microloops shall conform to the following requirements:

428.3.7.1.1 The microloop probe shall be sealed for moisture protection.

428.3.7.1.2 The microloop shall be capable of operating from -35F to +165F.

428.3.7.1.3 The microloop shall have a sensitivity of approximately 3.5 to 8 microhenries/oerstad at 40 KHZ and 0.2 to 0.6 oerstad ambient magnetic field.

# 428.3.8 EMERGENCY VEHICLE OPTICAL DETECTOR SYSTEMS

428.3.8.1 This work shall consist of furnishing and installing an Emergency Vehicle Optical Detector (EVOD) systems at signalized intersections on signal standards and in control cabinets in compliance with the specifications and the details shown in the plans.

428.3.8.2 The system shall employ optical communication to identify the presence of designated priority vehicles and cause the traffic signal controller to advance or hold a desired traffic signal display selected from phases normally available. The optical signal shall be encoded for vehicle identification and classification. The optical signal shall interface with software for record-keeping, logging, and intersection set-up.

428.3.8.3 The matched set of components which make up the Emergency Vehicle Optical Detector (EVOD) system shall cause the existing traffic controller to be

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manipulated upon recognition of the signal from the vehicle.

428.3.8.4 This communication shall be effective to the optical detectors at or near the intersection over a line-of-sight path of at least 2500 feet.

428.3.8.5 The EVOD system shall operate on a first come, first-served basis, or on a dual priority basis. The EVOD system shall be designed to yield to other priority demands such as railroad crossings.

428.3.8.6 The EVOD system shall interface with existing traffic signal controllers without compromising normal operation or existing safety provisions. The EVOD system shall consist of an optical emitter, optical detectors, optical detector cable, and encoded phase selectors.

428.3.8.7 To ensure desired performance, the EVOD system shall provide matched system components, proven through integrated testing and extensive functional experience. The matched system components shall offer compatibility with all types of traffic signal controllers, i.e., electromechanical, or solid-state. Matched components shall provide future system compatibility of all priority control elements.

# 428.3.8.8 EVOD OPTICAL EMITTER ASSEMBLY

428.3.8.8.1 EVOD optical emitters shall be a lightweight, weather resistant, light emitting device with internal regulated power supply.

428.3.8.8.2 The optical emitter assembly shall produce precisely times, crystal controlled optical energy pulses of high intensity light from a single source, at a rate of 14.035Hz or 9.639Hz depending on the emitter control switch employed. The optical emitter shall send an encoded signal to classify and identify the emergency vehicle.

428.3.8.9 EVOD OPTICAL DETECTOR

428.3.8.9.1 EVOD optical detectors shall be light weight, weatherproof, adjustable, single or dual directional optical detector assemblies.

428.3.8.9.2 Internal circuitry shall transform optical energy from the optical emitter assembly into electrical signals for delivery (up to 1000 feet) via optical detector

cable to the phase selection equipment.

428.3.8.9.3 The unit shall be of high impact polycarbonate construction with non-corrosive hardware and shall be designed for simple mounting at or near an intersection on mast arm, pedestal, pipe, or span wire and shall operate over an ambient temperature range of minus thirty degrees (-30°)C to plus sixty (+60°)C.

428.3.8.9.4 The unit shall be responsive to the optical emitter at a distance of at least 2500 feet and shall be capable of providing the necessary electrical signal to the phase selector through up to 1000 feet (305m) of optical detector cable.

## 428.3.8.10 EVOD OPTICAL DETECTOR CABLE

428.3.8.10.1 EVOD optical detector cable shall be durable, and shall have the necessary electrical characteristics to carry power to the optical detector from the phase selector and to carry the optical detector signal to the phase selector.

428.3.8.10.2 The cable shall have three (3) conductors AWG 20 (7 x 28) stranded and an individually tinned drain wire to provide signal integrity and transient protection. Cable conductors shall be copper and shall be shielded with aluminized polyester. The shield wrapping shall have a twenty percent (20%) overlap to ensure shield integrity following conduit and mast arm pulls.

428.3.8.10.3 The cable shall deliver the necessary quality signal from the optical detector to the phase selector over a non-spliced distance of 1000 feet (305m).

428.3.8.10.4 The cable shall deliver sufficient power to the optical detector over a non-spliced distance of 1000 feet (305m).

428.3.8.10.5 The cable insulation rating shall be 600 volts, minimum.

428.3.8.10.6 The cable temperature rating shall be eighty degrees (80°)C minimum.

428.3.8.10.7 The cable shall be color coded as follows:

1. Orange for delivery of optical detector power (+);

2. Blue for optical detector power return (-) or optical detector signal;

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3. Yellow for optical detector signal;

4. Bare for optical detector power return (-).

# 428.3.8.11 PHASE SELECTOR ASSEMBLY

428.3.8.11.1 The EVOD phase selection assembly shall interface between the optical detectors and the controller unit, shall not compromise the existing controller unit's fail-safe provision and shall provide sufficient power for up to three (3) optical detectors per channel.

428.3.8.11.2 The assembly shall provide suitable sensitivity to the optical detector signal, computer software, or encoded emitter on a maintenance vehicle.

428.3.8.11.3 The assembly shall be a plug-in, two (2) channel, dual priority device intended to be installed directly into the input file of control cabinets equipped with priority phase selection software.

428.3.8.11.4 The assembly shall be powered from AC mains and contain an internal, regulated power supply to power optical detectors.

428.3.8.11.5 The assembly shall be capable of recognizing the following pulse rates as delivered by the optical detectors:

- 1. 9639  $\pm$ 0.119 Hz as Frequency I;
- 2. 14.035 ±0.255 Hz as Frequency II.

428.3.8.11.6 The assembly shall deliver signals to the controller to cause selection of the desired phase green display for the approaching vehicle.

428.3.8.11.7 The assembly shall have a test switch for each channel to deliver Frequency I or Frequency II signal pulse rates to verify proper function at both optical emitter flash rates, first-come, first-served operation, and Frequency II override capability.

428.3.8.11.8 The assembly shall have a selectable call dropout time of five (5) or ten (10) seconds +2.5%.

428.3.8.11.9 The phase selector shall be a modular, microprocessor controlled, two (2) channel, four (4) phase, high priority device, expandable to a four (4) channel, eight (8) phase, dual ring controller. The phase selector module shall have memory and shall be programmable via a personal computer. The phase selector module shall have a communication port on the front panel.

428.3.8.11.10 The phase selector shall continuously monitor all GREEN, WALK, and pedestrian clearance displays for a smooth transition from controller to phase selector interval timing.

### 428.3.8.12 EVOD RELIABILITY

428.3.8.12.1 All equipment supplied as part of the optical priority remote traffic control system intended for use in the controller cabinet shall meet the electrical and environmental specifications spelled out in the NEMA standards publication TSI-1983 part 2.

428.3.8.12.2 All equipment supplied as part of the priority control system intended for use in on emergency vehicles shall operate properly over an ambient temperature range of minus thirty degrees  $(-30^{\circ})$ C to sixty degrees  $(60^{\circ})$ C and in air with relative humidity from five percent (5%) to ninety five percent (95%) and a vehicle battery voltage of from ten (10) volts to fifteen (15) volts.

428.4 CONSTRUCTION REQUIREMENTS.

# 428.4.1 LOOP DETECTOR

428.4.1.1 The installation of a loop detector consists of two distinct elements. The first element is the installation of the loop (inductive coil) in the pavement, at the location and geometry shown on the plans, including a low inductance lead-in cable back to the control cabinet. The second element is the installation of the loop vehicle detector module (sensing unit in the control cabinet, including all wiring to output the presence of a vehicle. Loop detector (total system) installations will not be accepted by the ENGINEER until it is demonstrated that the installation will accurately detect the presence of vehicles as required on the plans and in the specifications.

428.4.1.2 Loop detectors shall be installed in accordance to details on the plans and the following requirements and procedures:

428.4.1.2.1.1 Saw cuts shall be made in pavement of the dimensions and shape detailed in the plans, using an abrasive cutting wheel concrete saw. Saw cut shall be  $2\frac{1}{4}$  inches to  $2\frac{1}{2}$  inches deep and approximately  $1\frac{1}{4}$  inch wide. (A  $3\frac{1}{8}$  inch wide slot shall be used to install ducted loop detector wire).

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428.4.1.2.1.2 When a contract includes new pavement or additional paving material overlay, the saw cut and wire installation shall be made at least below the last paving lift of 5/8 inch or greater thickness. No saw cuts will be permitted in final lift of surfacing. In the case of pavement overlay, the saw cut shall be a minimum of  $2^{1}/_{4}$ inches below the final surfacing elevation. When the contract calls for heater scarification pavement treatment, the saw cuts shall be made after this operation has been completed.

428.4.1.2.1.3 Saw cuts intersecting at 40° or more shall be core drilled at intersection point to accommodate wire slack. One-inch to two-inch diameter holes are to be drilled at angle points to the same depth of the saw cuts. Cuts across concrete pavement expansion joints shall also be drilled at this point to allow wire slack. Saw cuts shall overlap by a sufficient length to provide a smooth bottom, even depth wire channel.

428.4.1.2.1.4 When there is more than one loop terminating at a pull box, each loop shall have a separate saw cut back to the box and these saw cuts shall be no closer than 6 inches.

428.4.1.2.2 A separate 1-inch rigid electrical conduit entrance shall be provided at the pull box for each loop. This conduit shall begin at the end of the pavement saw cut and run under any curb and gutter and sidewalk in conformance to the details in the plans. The ends of the conduit shall have all sharp edges removed and shall be "bushed". A 1" - 2" wide hole shall be broken out on the pavement end of the conduit. Wire through this hole shall be left slack and the end of the conduit shall be backfilled and sealed with a soft-setting butyl rubber or asphaltic joint sealer. The remaining portion of the hole shall be filled with the approved saw cut sealant.

428.4.1.2.3 A continuous run of loop detector wire shall be placed in the saw cut, wound around the coil section the number of turns shown on the plans or as directed by the ENGINEER. No more than four wires or turns shall be placed in a single saw cut. Loop detector wire pairs shall be twisted (four to six twists per foot) between the loop (thru the lead-in saw cut and conduit) to the shielded lead-in splice.

428.4.1.2.4.1 Before placement of the sealant and wire, the saw cut shall be cleaned of all debris and standing water by blowing out with compressed air. (The

pavement surface may be damp to the touch). The inside of the saw cut shall be free from any sharp protrusions such as from loose aggregate or uneven saw cuts.

428.4.1.2.4.2 Wire run through drilled corners and joint crossings shall be left slack. This slack portion of wire shall be encapsulated with a soft-setting butyl rubber or asphaltic joint sealer.

428.4.1.2.4.3 The following types of wire installation methods shall be used. (When the plans call for a specific method, only that method will be permitted).

428.4.1.2.4.4 All sealant shall be placed in a saw cut by means of a special nozzle. The saw cut shall be filled to approximately 1/8 inch of the top. No spill over onto the pavement surface will be permitted (any excess shall immediately be struck off). Sealant shall not be placed when the ambient temperature is below  $40 \square$  F. or manufacturer's requirements, or when precipitation is occurring or impending. The sealant will be considered part of the saw cut operation and no separate payment shall be made therefor.

428.4.1.2.4.5 Ducted loop detector wire may by installed during a paving operation by securely attaching the loop in the proper shape to the pavement surface and overlaying with the next paving lift(s) of 2 inches or greater total thickness. Means of securing the loop, before overlaying, may be by placing the ducted wire in slot cut in the pavement or by securing the corners by a method approved by the ENGINEER, then covering the wire by hand with a small amount of asphaltic paving material. Ducted loop detector wire shall not be bent less than a 1-inch radius.

428.4.1.2.4.6 Preformed loops and microloops shall be placed in accordance with the manufacturer's specifications.

428.4.1.2.5 When a multiple loop system (same channel) is used, adjacent loops shall be wound with opposite rotations. Rotation reversal may be accomplished by reversing leads at the pull box. The CONTRACTOR shall mark the beginning of the loop detector wire and the pull box before beginning the winding installation process to allow determining the direction of rotation. All multiple loops shall be connected in series to the lead-in cable at the pull box or splice point.

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428.4.1.2.6.1 Loop lead-in cable shall be run continuously from the loop detector wire splice to the terminal in the control cabinet. No splices in the lead-in cable will be permitted. The drain (ground) wire in the lead-in cable shall be connected to earth ground at the cabinet end only. The ground wire at the curb side pull box shall be neatly clipped off adjacent to the end of the outer jacket.

428.4.1.2.6.2 Connections between the loop detector wire and the lead-in cable shall be soldered. No open-flame torches shall be used for soldering. The splices shall be made waterproof by encapsulating the bared wire with a two-part sealant, 3-M #3570 connector sealant, or equal. The splices shall then be wrapped with a high quality, all-weather electrical tape or approved self-bonding tape, overlapping the wire insulation approximately 1 inch and of sufficient layers to equal 1½ times the thickness of the original insulation. The outer jacket of the cable shall be sealed in a similar manner except the tape shall overlap the outer jacket by four inches. When ducted loop detector wire is used, sealant shall be applied at the end of the tube portion then wrapped with tape to prevent water entry.

428.4.1.2.6.3 The "V" splices formed shall be suspended high in the pull box to prevent immersion in water.

428.4.1.2.7 After the loop installation in the roadway has been completed, each loop shall be checked with a megger to insure the integrity of the installation. The resistance of each loop shall be greater than 10 megohms at 500 volts. When called for by the ENGINEER, a check will be made of the completed loop detector system in accordance with this Section 428.

428.4.2 PUSH-BUTTON STATIONS: shall be mounted on the side of traffic signal poles as shown in the plans.

## 428.4.3 EVOD OPTICAL DETECTOR SYSTEM

428.4.3.1 EVOD optical detector systems shall be installed in accordance with the manufacturer's recommendations. The equipment manufacturer shall not modify the existing traffic controller unit beyond adding the necessary hardware to the traffic controller cabinet.

428.4.3.2 The manufacturer or its authorized representative shall be responsible for system check-out

prior to purchaser's acceptance by verifying proper installation per recommended interfaces, verifying that optical ranges are properly set, and verifying that phase selector timings or controller software timings are properly set.

428.4.3.3 The CONTRACTOR shall provide appropriate training for the OWNER's personnel and emergency vehicle operators, and assist in trouble shooting, maintenance, and system operation.

#### 428.5 MEASUREMENT AND PAYMENT.

428.5.1 Loop vehicle detector modules, preformed loops including lead, microloops, and push-button stations will be measured by the unit complete in place.

428.5.2 Loop detector wire, ducted loop detector wire, loop lead-in cable, and loop detector saw cut will be measured by the linear foot complete in place.

428.5.3 Emergency vehicle optical detector system components including phase selector racks, phase selector modules, "D" panels (including cables and harnesses), optical detectors, and optical emitters will be measured by the unit complete in place. Optical detector cable will be measured by the linear foot complete in place.

428.5.4 The accepted quantities of loop vehicle detector modules, preformed loops, microloops, push-button stations, loop detector wire, ducted loop detector wire, loop lead-in cable, loop detector saw cut, and emergency vehicle optical detector system components including phase selector racks, phase selector modules, "D" Panels (including cables and harnesses), optical detectors, optical emitters, and optical detector cable will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown on the bid proposal.

## TRAFFIC SIGNAL CONTROLLERS

429.1 GENERAL: This work shall consist of furnishing and installing traffic actuated controllers, special auxiliary control equipment, and cabinets in compliance with the specifications, details shown on the plans, and Standard Drawings at the locations shown on the plans, or as established by the ENGINEER.

429.2 REFERENCES.

- 429.2.1 Manual on Uniform Traffic Control Devices (MUTCD), Latest Edition
- 429.2.2 National Electrical Code (NEC), Latest Edition
- 429.2.3 National Electrical Manufacturers Association (NEMA) Standards, Latest Edition
- 429.3 MATERIALS.
- 429.3.1 TRAFFIC-ACTUATED CONTROLLER
- 429.3.1.1 General.

429.3.1.1.1 These specifications together with the NEMA Standards Publication TS-1-1989 or latest edition for Traffic Control Systems describe required features, functions, and test procedures for traffic actuated controllers. These specifications shall be considered in addition to the minimum requirements for a NEMA controller. All controllers furnished shall be of a modular design microprocessor type, unless otherwise called for on the plans or special provisions.

429.3.1.1.2 All input/output electrical connections for all standard and special functions shall be multi-terminal, MS type plugs on the front of the controller, conforming to the latest NEMA interface standards. (RS-232-C ports may be used for communications and special functions).

429.3.1.1.3 All controllers shall meet all requirements for a solid state NEMA traffic actuated controller and shall utilize the latest state-of-the-art design employing microprocessor and CMOS logic circuitry.

429.3.1.1.4 All controllers shall use a keyboard for entry of all operator timing and functional data into nonvolatile memory. The keyboard shall be of a type providing tactile feedback when depressed. The procedure required to enter, revise and display operator data shall be menu driven and designed to minimize the number of key strokes; all key functions shall be marked on the front of the controller, clearly and easily readable by the operator. The display shall be LCD with adjustable contrast and back lighting. The operator data shall be retained in memory for a minimum of 30 days after removal of primary power.

429.3.1.1.5 All controllers shall be capable of being programmed in different patterns of phase sequences: quad-left (NEMA), sequential, or combination of concurrent and sequential. All controllers shall permit programming of phases as inactive. The signal plan shall be pre-programmed by the manufacturer as called for on the plans. This signal plan (sequence, inactive phases, any overlaps, and/or preempt sequences) shall be nonvolatile (not held exclusively in RAM). All programmed data shall be retained in non-volatile EEPROM. In addition, battery backup shall be provided in the same module for the purpose of power down clock operation and battery backed RAM for non-programmed data, such as message logs.

429.3.1.1.6 All controllers shall be of modular design consisting of a main processor board (MPU) input/output interface, and the power regulation. The power transformer and capacitors may be rigidly fixed to the frame. Modules may be directly removable from the front of the controller. The keyboard and LCD displays shall be on the front of the controller. Provisions shall be made in the design to allow time base coordination and preemption programming through the controller keyboard.

429.3.1.1.7 All controllers shall be furnished with a front panel mounted RS 232-C industry standard input/output port. This port shall be capable of printing out program data to a stand alone printer; direct interface with a personal computer for uploading and downloading program data; and direct interface with a dial-up modem for remote communications with a personal computer over telephone lines. These connections shall be done such that there is no interruption to the signal operation.

429.3.1.1.8 All controllers shall have LCD alphanumeric displays for timing, status and programming information. Each ring shall be provided with a separate display (simultaneous dual ring display). The display shall have two modes of operation (run and program). In the run mode, current phase, interval and interval time remaining shall be displayed. In the programming mode, the phase, interval or programmable function, and the

## TRAFFIC SIGNAL CONTROLLERS

time or value shall be displayed. The controller shall permit the display of an operator-entered time or value before entering into memory, and shall provide for the automatic sequencing through the programming to minimize the required key strokes. It shall be possible to enter a four digit numeric security code to prevent unauthorized changes under the programming mode. Access to stored information shall be available at all times.

429.3.1.1.9 Internal preemption shall be furnished for all controllers, providing railroad and/or emergency vehicle preemption sequences. Preemption shall provide as a minimum, six independent preemption programs. It shall be possible to prioritize preemption, delay before preemption, cycle during preemption by hold phase assignments, and provide for pedestrian clearance through initial clearance yellow. All intervals to preemption shall be timed and all operator data shall be programmed through the controller keyboard. All operator-entered preempt data shall be made available on the printer hard copy. The furnished preempt sequencing and operation shall be as called for on the plans. All railroad preemption shall be in conformance with MUTCD requirements and include a track clearance phase. Return to normal controller operation shall be in accordance with the plan phasing diagram and a detector call shall be placed on phases as noted.

429.3.1.1.10 Internal time base coordination shall be furnished for all controllers providing the synchronization and control functions for coordinating actuated signalized intersections without the use of interconnecting cables. Coordination shall be made on a time of day, day of week and week of year basis. The coordinator shall function as a standard signal system coordinator using Force Offs, Holds and Phase/Ped Omits outputs and phase green inputs, capable of supervising the controller. The coordinator shall keep to the accuracy of the AC line frequency, and without line voltage to accuracy of at least +.005% (+50 ppm). The battery backup shall maintain real time and memory for at least 720 hours. The time clock shall keep track of time of day in seconds, day of week and week of year. It shall be possible to program for automatic Daylight Saving Time changes. In the event of a power disruption, the coordinator shall automatically upload itself upon return to line voltage. The coordinator shall have the minimum availability of 160 program changes, selectable on the minimum basis of 10 daily program groups, two weekly programs, and 10 exception day (holiday) programs. The program change (on or off of any single function) shall be selectable at

least to a minute of any hour of a day. The coordinator shall have minimum selectable system options of 4 cycles, 4 splits per cycle, 3 offsets per cycle, 3 permissive periods per split, one pedestrian permissive period per split, and 3 force offs per split. Cycle settings shall be selectable from 0 to 255 seconds in one-second increments, or as a percentage of the cycle length. Offsets, permissive periods, and force off points may be programmable from 0 to 255 seconds in one-second increments or as a percentage of the cycle length. Offset seeking shall be selectable for dwell or shortway offset transitions. It shall be possible to manually select any program. The coordinated phase(s) shall selectable and shall be programmed as called for on the plans. Display(s) shall be provided to allow the user (with keyboard control) to display the current time of day, week of year, cycle countdown, current plan in effect, hold, force off, sync outputs, and all programmed data as they occur.

#### 429.3.1.2 GENERAL DESIGN REQUIREMENTS

#### 429.3.1.2.1 COMPONENTS

429.3.1.2.1.1 All timing circuits shall consist entirely of solid state electronic circuitry consistent with the state-of-the-art large scale integration circuit (LSI) techniques. The CONTRACTOR shall furnish cross reference and data sheets showing the parameters of all solid state devices used.

429.3.1.2.1.2 All switching functions shall be accomplished through the use of solid state electronic circuitry. No electromechanical devices, such as rotary, stepping, or line-switches, or time/break relays, shall be used for switching functions.

429.3.1.2.1.3 All printed circuit boards (assemblies) shall be of glass epoxy, two-ounce copper circuit traces, conforming to NEMA requirements for traffic signal controllers. Current carrying traces shall be covered with a solder mask material, and those boards containing a major number of CMOS components shall be coated with a humidity sealant. In addition, circuit reference designation for all components shall be clearly marked immediately adjacent to the component.

429.3.1.2.1.4 All components shall be amply derated with regard to heat dissipating capacity and rated voltage so that with maximum ambient temperature and maximum applied voltage, material shortening of life or shift in values shall not occur.

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429.3.1.2.1.5 The design life of all components under 24 hour-a-day operating conditions in their circuit applications shall not be less than five years.

429.3.1.2.2 CONSTANCY OF INTERVALS: Constancy of Intervals. The controller shall be of such design that the length of any interval, portion, period, or unit extension may be set to two significant digits and will be and remain within  $\pm 100$  milliseconds of that setting if the line voltage is at any value from 95 volts to 135 volts, the ambient temperature is between -30 degrees F and +165 degrees F, and the line frequency is 60 hertz plus or minus 0.3 hertz. This performance shall include cold and hot starts and shall be obtained without the use of power-consuming heating or cooling apparatus of any kind.

429.3.1.2.3 POWER: The controller and all associated equipment shall be designed for use on 115-volt, 60-cycle, single phase AC.

429.3.1.2.4 MECHANICAL CONSTRUCTION.

429.3.1.2.4.1 The controller shall be housed in either a sheet aluminum, steel, or approved housing with a durable finish.

429.3.1.2.4.2 The controller shall be modular by design, conforming to microprocessor type specification.

429.3.1.2.4.3 Printed circuit boards shall be designed to plug into receptacles within the controller.

429.3.1.2.4.4 Printed circuit boards shall be provided with secure fastening devices to prevent falling out during transportation or handling.

429.3.1.2.4.5 All assemblies shall be interchangeable between controllers of the same manufacturer and series.

429.3.1.2.5 ENVIRONMENTAL: All controllers shall conform to NEMA Standards for Environmental, Interface, and Functional Requirements.

429.3.1.3 CONTROL REQUIREMENTS.

429.3.1.3.1 GENERAL: Operator timing and functional programming shall be accomplished on the front panel of the controller. Programmed NEMA overlap boards may be inserted in a slot provided on the front panel or internally within the controller. Operator programming shall be by digital switches or keyboard entry, consistent with these specifications.

429.3.1.3.2 PHASE TIMING: The following timing intervals shall be provided for each traffic phase. The interval and minimum range of adjustment of the timing intervals shall be:

	TIMING RANGE	MAX RESOLUTION
INTERVAL	(SECONDS)	(INCREMENTS)
Minimum	0-99	1
Extension (Gap)	0-9.9	0.1
Yellow Change	0-9.9	0.1
Red Clearance	0-9.9	0.1
Maximum (MAX 1	l) 0-99	1
Maximum (MAX 2	2) 0-99	1
Walk*	0-99	1
Ped. Clearance*	0-99	1
Red revert**	2-7	1

\* Need be furnished with each through traffic movement phase only.

\*\*Per controller or ring; may be internal setting.

429.3.1.3.3 PHASE CONTROL FUNCTIONS: Each phase shall be capable of being set to the following functions:

429.3.1.3.3.1 MAX RECALL (NON ACT): automatically returns phase and extends green timing to that of MAX GREEN. In absence of opposing phase demand, the controller shall rest in GREEN.

429.3.1.3.3.2 PED RECALL (NON ACT): automatically returns phase to WALK-PED CLEARANCE and vehicle right of way without vehicle and Pedestrian demand.

429.3.1.3.3.3 VEH. RECALL (EXT.): automatically places a recurring demand for vehicle service without actual vehicle demand when not in its green interval.

429.3.1.3.3.4 NON LOCKING (MEMORY OFF): phase operates in fully actuated mode; memory of vehicle demand is retained only when a vehicle is in the detection zone (detector outputting).

429.3.1.3.3.5 LOCKING (MEMORY ON): phase operates in fully actuated mode; memory of vehicle

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demand (detector output) is retained in the phase until that phase is served.

#### 429.3.1.4 OPERATIONAL REQUIREMENTS

#### 429.3.1.4.1 TIMING REQUIREMENTS

429.3.1.4.1.1 The clearance period shall consist of time intervals of preset duration, namely:

- (1) Yellow Change Interval.
- (2) Red Clearance Interval.

429.3.1.4.1.2 Each phase shall be provided with an initial interval control determining the guaranteed minimum green period for that phase. With a pedestrian actuation or a pedestrian and vehicle actuation, the minimum green shall consist of the sum of the walk interval and pedestrian clearance interval or minimum green interval, whichever is greater.

429.3.1.4.1.3 Each phase shall be provided with an extension interval control which shall provide vehicles added green time beyond the minimum green time by vehicle actuation(s). Successive actuations shall cancel the remainder of the previous extension interval and shall initiate a complete new extension interval for the vehicle which provided the actuation. Should transfer of right of way occur while an extension interval is unexpired, the right of way shall be returned at the next opportunity in the cycle.

429.3.1.4.1.4 Each phase shall contain two maximum green timing interval controls which shall set a limit on the length of time that continuous traffic on the right of way phase can extend the right of way for that phase after an actuation is registered for any conflicting phase. Normal operation shall be in the (MAX 1) maximum interval. The second (MAX 2) maximum interval shall be effected by both an external and internal input.

429.3.1.4.1.5 Actuation of a pedestrian push button during a pedestrian clearance interval or at any other time while the pedestrian "Don't Walk" signal is being displayed shall register the presence of said pedestrian. This actuation shall be remembered so that the pedestrian walk indication will be accorded at the next assignment of right of way to the phase.

429.3.1.4.1.5.1 In the event of a registered pedestrian actuation on a phase with no demand for pedestrian or vehicular right of way on a conflicting phase, the phase

shall be capable of recycling and providing pedestrian and pedestrian clearance intervals.

429.3.1.4.1.5.2 The minimum and guaranteed pedestrian protection shall consist of the pedestrian clearance interval. During the balance of the right of way and clearance intervals the "Don't Walk" shall be steady.

#### 429.3.1.4.2 PHASING REQUIREMENTS

429.3.1.4.2.1 Right of way shall not be given to any street without an actuation (call) and, in complete absence of traffic (or recall option), right of way shall remain on the street where it was last assigned unless RED REST option has been exercised; then the controller shall cycle to all red and remain until a phase call.

429.3.1.4.2.2 All controllers shall operate as a concurrent phase timing (dual ring) controller, or sequential (single ring) configuration. All phases shall be identified (numbered) and operate in accordance with a NEMA dual ring (quad-left) configuration or sequential configuration. All controllers furnished shall be capable of operating eight field phases. Controllers shall be capable of assigning the right of way to a single phase or any combination of non-conflicting phases, and shall normally operate in the mode specified on the plans. Phases skipped on each ring for no demand and recall functions for each phase shall be as specified for sequential controllers. Controllers shall have the capability of providing four overlap phases in any phase combination, programmable on both a standard NEMA plug-in overlap program board and operator keyboard entry.

429.3.1.4.3 All controllers shall have all input/output features per phase, ring and unit as required under NEMA Standards. Any unused inputs/outputs shall be wired to and identified on the controller back panel.

429.3.1.4.4 All controllers shall have an initialization control to start at the beginning of the programmed GREEN, YELLOW, or RED interval of the selected phase(s), as called for on the plans, application of power or the EXTERNAL START input. Vehicle and pedestrian calls shall then be placed on phases.

## 429.3.2 SYSTEM MASTER

429.3.2.1 A system master shall be a traffic adjusted system master (arterial or multi system as specified) of a microprocessor or computer design. When specified on

## TRAFFIC SIGNAL CONTROLLERS

the plans, peripheral equipment, communication equipment and/or a cabinet shall be part of this item. The exact location shall be as called for on the plans. All system masters shall conform to the design, operational, and communication requirements called for on the plans and/or special provisions.

429.3.2.2 All units shall be shelf mounted in the controller cabinet with MS or RS-232 type connectors, and shall be housed in a metal cabinet; conforming to this Section 429.

429.3.3 CABINETS, SUPPORT EQUIPMENT, AND WIRING

429.3.3.1 GENERAL

429.3.3.1.1 Unless otherwise specified on the plans the components of the controller shall be provided in a sturdy, weatherproof metallic housing hereinafter referred to as a controller cabinet

429.3.3.1.2 Unless otherwise specified on the plans, all cabinets shall be wired for the full application of all phases, pedestrian signals on all through movements, and all normal overlaps for either four phase-single ring operation, or eight phase-dual ring operation. All vehicle detection shall be wired. The cabinet shall be furnished so that to implement any initially unused phases or functions, it shall only be necessary to add load switches, vehicle detectors, disconnect any jumpers and rearrange field conductors.

429.3.3.1.3 All ground mounted cabinets shall be #14 gauge sheet steel or 0.125 inch minimum thickness type 5052-H32 aluminum. Pedestal cabinets shall be aluminum of 0.125-inch minimum thickness cabinets shall be designed and manufactured for rigid mounting whether intended for pole or pedestal mounting. The cabinets shall not flex on their mounts. The specific types of controller cabinets and their internal components and wiring arrangements for a particular installation shall be as necessary to provide a complete operating traffic control system as called for on the plans or in the special provisions, and as follows:

429.3.3.1.3.1 The cabinet shall have a main door which shall be equipped with a Corbin tumbler lock number 1548-1 and an auxiliary door equipped with a treasury type lock Corbin Number R357SG5 for a police key. The main door handle shall have provisions for padlocking in the closed position. A rain channel shall be incorporated

into the design of the main door opening to prevent liquids from entering the enclosure. The cabinet door must be a minimum of 80% of the front surface of the cabinet. A stiffener plate shall be welded across the inside of the main door to prevent flexing. The top of the cabinet shall incorporate a slope toward the rear to prevent rain accumulation. All seams shall be sealed with RTV sealant or equivalent material on the interior of the cabinet. The main door and police door-in-door shall close against a weatherproof and dust proof closed cell neoprene gasket seal. The lower section of the cabinet door shall be equipped with a louvered air entrance. The air inlet shall be at least 16 inches by 20 inches in size. Louvers must satisfy the NEMA rod entry test for 3R ventilated enclosures: A non-corrosive, vermin and insect proof, removable air filter shall be secured to the air entrance. The filter shall fit snugly against the cabinet door wall. The main door hinge shall be a one piece, continuous piano hinge with a stainless steel pin running the entire length of the door mounted on the right side when facing the cabinet. The hinge shall be attached in such a manner that no rivets or bolts are used.

429.3.3.1.3.2 Substantial metallic shelves or brackets to support the controller and auxiliary equipment shall be furnished and installed. A minimum of two (2) shelves shall be provided, unless approved otherwise. The shelves shall be adequately supported at both ends by angle-type braces. The shelves shall be of sufficient strength to prevent the shelf from sagging with the full weight of the control equipment.

429.3.3.1.3.3 Control cabinets shall be of sufficient size to allow the controller assembly and all associated equipment to stand in an upright position on the shelving. No equipment shall be placed on the floor of ground mounted cabinets. The control cabinet shall be of sufficient size to allow the removal of the controller assembly by pulling this assembly straight out. It shall not be necessary to turn the assembly sideways to remove it from the cabinet. The cabinet shall be of sufficient size to allow the door to be closed with no interference to the wire harness running to the door. All equipment and wall mounted devices shall be capable of being removed without relocating or unjacking one device to another device. Cabinet wiring shall be such that the front panels of control equipment are not obscured.

429.3.3.1.3.4 The minimum acceptable cabinet size shall be as follows or as specified on the plans or in the special provisions, provided that the above mentioned space requirements are met:

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TYPE OF CAB.	OUTSIDE DIMENSIONS HxWxD	USE
G	33" X 20" X 14"	When called for on plans
М	48" X 30" X 16"	When called for on plans
MSX	57" X 30" X 17"	When called for on plans
Р	54" X 38" X 24"	4-Phase single ring
		operation
Р	54" X 38" X 24"	8-phase dual ring
		operation
R	72" X 38" X 24"	When called for on plans

429.3.3.1.3.5 All cabinets for controllers shall be of the ground mount type with internal bolts, unless otherwise called for on the plans. Anchor bolts and templates for their installation shall be shipped as soon as possible to the CONTRACTOR so that the necessary concrete base may be installed in advance of receiving the controller.

429.3.3.1.3.6 All cabinets shall be finished as follows:

a. Steel Cabinets, Inside and Outside.

First Coat. Flow Stage Iron Phosphate coating Second Coat. TGIC Polyester Power Coat paint matching Federal Standard 595A Color Chip 27886, with a minimum dry film thickness of 2 mm.

b. Aluminum cabinets: No paint required.

c. Special projects: Finish either steel or aluminum cabinets as designated on plans.

429.3.3.2 CABINET WIRING, TERMINALS AND FACILITIES: These specifications together with NEMA Standards, describe the requirements for wiring, terminals and facilities within the cabinet.

## 429.3.3.2.1 CABINET WIRING

429.3.3.2.1.1 All cabinet wiring shall be neat and firm and all harness and cabinet wiring shall be laced or bound together with Ty wrap or equivalent.

429.3.3.2.1.2 All back panel wiring shall conform to the following gauge and color:

Grn/walk loadswitch out - brown wire - 14 gauge

Yellow loadswitch out - yellow wire	- 14 gauge
Red/don't walk loadswitch out - red wire	- 14 gauge
CMU (other than AC pwr) - violet wire	- 22 gauge
Controller I/O - blue wire	- 22 gauge
AC+(pwr panel to main panel) - blk wire	- 8 gauge
AC+(main panel) - blk wire	- 10 gauge
AC-(pwr panel to main panel)- white wire	- 8 gauge
AC-(main panel) - white wire	- 10 gauge
Chassis ground (pwr panel) - green wire	- 8 gauge
DC ground - grey wire	- 22 gauge
Flash programming- orange wire	- 14 gauge

429.3.3.2.1.3 All wiring, 14 AWG and under, shall conform to MIL-W-I6878/1, type B/N, 00V, 19 strand tinned copper. The wire shall have a minimum of 0.010 inch thick PVC insulation with clear nylon jacket and rated to 105 degrees Celsius. All 12 AWG and larger wire shall be UL listed THHN/THWN 90 degrees celsius, 600 V, 0.020 inch, thick PVC insulation and clear nylon jacketed.

429.3.3.2.1.4 All connecting cables and wire runs shall be secured by mechanical clamps. Stick-on type clamps are not acceptable.

429.3.3.2.1.5 Logic ground and chassis ground shall be isolated from each other within the cabinet In addition, chassis ground and AC- shall not be tied together within the cabinet.

429.3.3.2.1.6 All wire at solder joints shall be hooked or looped around the eyelet or terminal block post prior to soldering to insure circuit integrity. Lap joint soldering is not acceptable.

429.3.3.2.1.7 All back panel, D interface panel, and detector panel terminal blocks should be permanently numbered and labeled as to their function.

429.3.3.2.2 BACK PANEL

429.3.3.2.2.1 A back panel shall be provided for termination of all DC logic wiring. This panel shall be located on the back of the cabinet below the equipment shelves and shall include the load bay and the flasher/flasher relays. All terminals and plug-in units shall be readily accessible without moving any equipment.

429.3.3.2.2.2 The back panel shall be a pre-wired type with the controller harness, conflict harness, and detector inputs permanently wired to the back of the panel.

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Connections for DC wiring shall be 1/4-inch quick connect tab type, 300 Volt and 20 amp. rated, the wire being mechanically stripped 1/4-inch and the tab firmly crimped covering wire and insulation, or soldered. All AC connections on the panel back and all connections to the load switch/flasher receptacles shall be soldered. All NEMA functions shall be brought out to the front of the panel with screw type connector. It shall be possible to program on the front, using jumpers (clips or wires), the signal outputs for all the types of phasing operations possible for the specified controller and to access all NEMA functions on the front for future auxiliary equipment. The terminal functions shall be clearly marked with the appropriate NEMA designation. When auxiliary equipment logic is called for on the plans, these connections shall be made on the front of the panel.

429.3.3.2.2.3 The panel shall be mounted to the cabinet so as to allow sufficient clearance between the cabinet wall and the panel's back connections. It shall be possible to drop the panel in the field (access back wiring) using simple hand tools. The load bay, including flasher, shall be a rack-mounted type. The load switches and flasher shall be adequately supported after insertion to prevent falling out due to vibrations.

429.3.3.2.2.4 The following minimum positions for plug-in units shall be provided:

	LOAD		RELAY
	SWITCH	FLASH	NEMA
TYPE OF CAB.	POSITION	POSITION	FLASHER
4 phase single ring	8	2	1
8 phase dual ring	16	4	1

429.3.3.2.3 POWER DISTRIBUTION PANEL: The power distribution panel shall be provided on the lower right-hand side of the cabinet and shall be fully enclosed with a removable cover to prevent accidental shock. The power panel shall include the main power feed terminal (barrier type), the required AC protection from lightning (EDCO SHP-300 surge arrestor or approved equal), filter (RFI), MOV to ground, and any NEC requirements.

429.3.3.2.4 DETECTOR PANEL

429.3.3.2.4.1 A detector panel shall be provided on the left-hand side of the cabinet.

429.3.3.2.4.2 Terminal blocks (barrier type), with removable buss bars shall be provided for all detectors and pedestrian push-button field conductors as required on the plans. The detector rack shall include the "J" pin conductor appropriately terminated for extend/delay operation.

TYPE	DETECTOR	DETECTOR
OF	RACK	TERMINAL
CABINET	POSITION	BLOCKS
4 phase single ring	16	20
8 phase dual ring	16	32

8 PHASE DUAL RING OPERATION 16 POSITION DETECTOR RACK (MINIMUM FOR EACH CABINET) U=Unit

<u>U 1</u>	<u>U 2</u>	<u>U 3</u>	<u>U 4</u>	<u>U5</u> <u>U6</u>	<u>U 7</u>	<u>U 8</u>
PH1	PH2	PH6	PH2EC	PH3 H4	PH8	PH4EC
PH5	PH2	PH6	PH6EC	PH7 PH4	PH8	PH8EC
U=UNIT						

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<u>U 9</u>	<u>U 10</u>	<u>U 11</u>	<u>U 12</u>	<u>U 13</u>	<u>U 14</u>	<u>U</u> 15	U <u>16</u>
SD1	SD3	SD5	SD7	SD9	PED	EVP1	EVP3
SD2	SD4	SD6	SD8	SD10	ISO	EVP2	EVP4
			U	U=UNIT			

4 PHASE SINGLE RING OPERATION 8 CHANNEL DETECTOR RACK (MINIMUM FOR EACH CABINET)

<u>U 1</u>	<u>U 2</u>	<u>U 3</u>	<u>U 4</u>	<u>U 5</u>	<u>U 6</u>	<u>U 7</u>	<u>U 8</u>
PH1	PH2	PH4	PH2EC	SD1	SD3	PED	EVP1
PH3	PH2	PH4	PH4EC	SD2	SD4	ISO	EVP2
			U=U	JNIT			

429.3.3.2.4.3 Connector/Pin assignments (2x22 pin edge card connector with 0.156 inch contact centers, key slots located between B & C and M & N) shall be as follows:

A = DC (-) Common
1 = Call Delay Inhibit (Channel 1)
B = DC (+) Power
2 = Call Delay Inhibit (Channel 2)
C = Reset
4 & D = Loop #1
5 & E = Loop #1
F = Output #1A Optocoupler (Collector)
H = Output #1A Optocoupler (Emitter)
8 & J = Loop #2
9 & K = Loop $#2$

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All pins not listed are spares.

429.3.3.2.5 "D" CONNECTOR PANEL: A "D" connector panel with harness shall be provided with each cabinet assembly on the left hand side of the cabinet, fully wired to provide all functions. All terminal blocks shall be barrier type. The panel shall contain provisions for mounting two (2) 120 volts AC relays for preempt inputs 1 and 2, and 1/4 AMP fuses for each relay.

429.3.3.2.6 TERMINALS: All terminals shall be numbered and identified with nomenclature that corresponds to the nomenclature on the controller assembly wiring diagram.

429.3.3.2.7 TELEMETRY INTERFACE

429.3.3.2.7.1 A telemetry interface harness and printed circuit board interface panel shall be supplied with each cabinet assembly. All terminal blocks shall be barrier type. As a minimum, the following input/output shall be accessible from the telemetry interface panel.

Local Controller Command Lines 1 & 2. Local Controller Read Back Lines 1 & 2. Master Controller Command Lines 1 & 2. Master Controller Read Back Lines 1 & 2. Chassis Grounds. Four Special Function Outputs. Eight System Detector Inputs. Flash Input. CMU Flash Input.

429.3.3.2.7.2 A socket mounted communication line transient protection device shall be supplied with the telemetry interface panel. The transient protection device shall be wired in series with the telemetry communications circuit.

429.3.3.2.7.3 Communication line impedance shall be matched to the transmitter output impedance to minimize noise on the line.

429.3.3.2.8 SYSTEM MOV RATING: When a system master is called for, MOV rating shall be provided on the DC outputs (controller inputs) when not provided internal to the unit.

#### 429.3.3.2.9 WIRING DIAGRAMS

429.3.3.2.9.1 Four sets of wiring diagrams (one shall be mylar type) shall be furnished for each cabinet. The cabinet shall be equipped with a plastic envelope to house one or more cabinet wiring diagrams. These wiring diagrams shall be furnished with the equipment submitted to the ENGINEER before testing will begin.

429.3.3.2.9.2 The cabinet wiring diagrams shall show and identify the connectors for all equipment and switches, relays, flashers, etc.

429.3.3.2.9.3 The diagrams shall also have a complete intersection sketch, with street names and north arrow including labeling of signal heads and detectors and a signal sequence chart identified and related to the intersection sketch.

429.3.3.2.10 ADDITIONAL ITEMS: The following additional terminals, protection devices, and switches shall be furnished for all cabinets:

429.3.3.2.10.1 A UL listed circuit breaker for filtered AC power serving all solid state devices including load switches, sized as follows:

- (1) 40 AMP protection for four phase single ring assemblies.
- (2) 50 AMP protection for eight phase dual ring assemblies.

429.3.3.2.10.2 A separate 20 AMP breaker for AC circuit serving the G.F.I. outlets, fan and light.

429.3.3.2.10.3 Terminal blocks (barrier type) for all AC+ connections.

429.3.3.2.10.4 Copper ground strip, mounted and ground to cabinet wall, for connection of all common conductors.

429.3.3.2.10.5 All field signal output circuits shall be terminated on an unfused barrier type terminal block with a minimum rating of 15 amps. AC field terminals shall have a number 10-32x7/16 inch screw as a minimum. All

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field input/output terminals shall be identified by permanent numerical marking strips. All field flash sequence programming shall be accomplished at the field terminals with the use of screwdriver only. Field terminal blocks shall be wired to use four positions per vehicle or overlap phase (green, yellow, red, flash). It shall not be necessary to debuss field terminal blocks for flash programming.

429.3.3.2.10.6 Terminal blocks (barrier type) shall be provided to terminate a special equipment harness. These terminals shall be located on the right-hand side of the cabinet, above the power distribution panel.

429.3.3.2.10.7 Terminals for connecting interconnect cable tie points and intercabinet termination when required. Transient protection (MOV with rating or as called for on the plans) shall be provided on all external lines.

429.3.3.2.10.8 One duplex G.F.I. convenience outlet shall be furnished for energization of test equipment, tools, and lighting. A second duplex G.F.I. convenience outlet, wired to filtered AC power, shall be furnished for telemetry equipment. The G.F.I. convenience outlets shall be NEMA type 5-15R.

429.3.3.2.10.9 Switches behind police auxiliary door.

429.3.3.2.10.9.1 Main switch, identified "On-Off," wired to turn off signal light power when switched to off position and to de-energize the controller and auxiliary equipment. This switch and connecting wiring, shall be rated at 50 AMP minimum.

429.3.3.2.10.9.2 Auto flash switch, identified "Auto Flash," wired to keep controller energized and to place signals on flash when switched to flash position. The controller shall have stop timing applied when in the flash position.

429.3.3.2.10.10 Interior Cabinet Switches.

429.3.3.2.10.10.1 The interior switches below and convenience outlet specified above shall be combined on a single panel and mounted on the back side of the cabinet door unless otherwise noted. All switches except main switch shall be heavy duty and rated 15 AMPS minimum. Momentary push buttons shall be rated at 1 AMP minimum for all vehicle and pedestrian inputs to the controller. Any exposed terminals or switch solder points shall be covered with a non-flexible shield to prevent

accidental contact. All switch functions must be permanently and clearly labeled. All wire routed to the police door and test push button panel shall be adequately protected against damage from repetitive opening and closing of the main door.

429.3.3.2.10.10.2 Test Switch. Two-position switch, identified "Auto Flash," wired to de-energize the signal light power when switched to flash position and to permit the controller to cycle through its normal sequences while displaying flash indications on signals.

429.3.3.2.10.10.3 Controller On/Off Switch. Twoposition switch, identified "Controller On/Off," wired to de-energize the controller and auxiliary equipment when switched to the off position.

429.3.3.2.10.10.4 Vehicle and Pedestrian Detector Switches. Two position momentary switches labeled "ON TEST" wired to each vehicle and pedestrian detector input for permitting the substitution of manual call into each controller detector input. Identify switches as to phase/function.

429.3.3.2.10.10.5 Preemption Test Switches. Test switches shall be provided to permit a manual preempt input. Each preemption phase shall have a separate switch with each phase appropriately identified.

429.3.3.2.10.10.6 Conflict Monitor Door Switch. The cabinet shall include a switch that prevents a signal from full operation without the conflict monitor property connected to the cabinet harness.

429.3.3.2.10.10.7 Door Open Switch. The cabinet shall include a door switch to log an event to the system master that the door is open.

429.3.3.2.10.10.8 Fluorescent Light Door Switch. The cabinet shall include a door switch that turns the cabinet fluorescent light on when the cabinet door is open.

429.3.3.2.10.11 Radio line filter (RFI) for filtering AC+ lights and control power for solid state light control and controller operation.

429.3.3.2.10.12 Pedestrian push-button isolation (field circuit) shall be rack mounted to protect solid state devices from transient voltages, i.e., prevent transients from being induced in the open pedestrian push-button circuits by isolation transformer(s), or by optoisolation.

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## 429.3.3.3 ADDITIONAL CABINET FEATURES

429.3.3.1 Cabinet Fan. A fan shall be mounted in the controller cabinet and shall be thermostatically controlled and shall turn on at a cabinet temperature manually adjustable through a range of 70 degrees F to 160 degrees F. The fan and cabinet vent holes shall be located with respect to each other so as to direct the bulk of the air flow over the controller unit. The inside opening shall be covered with ¼-inch maximum mesh screening to prevent the operator from accidentally coming in contact with moving fan blades. The cabinet intake fan vent here shall be filtered.

429.3.3.2 Fluorescent Light. A fluorescent fixture and lamp shall be mounted in the cabinet over the door, positioned so as to minimize damage when sliding equipment off shelves. The fluorescent fixture shall be for an F20T12 lamp in all ground mounted cabinets and for an F15T12 lamp in pedestal cabinets. The lamp shall be packaged separately when transported to avoid breakage. The fluorescent light shall be turned on by use of a door switch.

429.3.3.3 Door Stops. Each controller cabinet door which is 22 inches or more in width or 6 square feet or larger in area shall be provided with a stop to limit door opening to both 90 degrees and 180 degrees, plus or minus 10 degrees. The stop shall be provided with a catch which can be operated when the door reaches the extreme open position and which will hold the door open securely until released.

# 429.3.3.4 SOLID STATE SIGNAL AND PEDESTRIAN LOAD SWITCHES

429.3.3.4.1.1 All signal load switches shall be external to the controller and shall be carried in the back panel load bay.

429.3.3.4.1.2 In addition to this specification, all signal control load switches shall conform to NEMA Standards.

429.3.3.4.2 The signal control assembly shall consist of a separate plug-in unit containing control circuitry for the operation of three separate signal lamp circuits. Vehicle and pedestrian control assemblies shall be interchangeable. Any unused output of each control assemble shall not be used for any other function or phase.

429.3.3.4.3.1 Circuitry shall consist of solid state

electronic components. No mechanical relays shall be used for the opening and closing of signal light circuits or for any other purpose.

429.3.3.4.3.2 The design life of all components under 24 hours per day operating conditions in their circuit application shall not be less than five years.

429.3.3.4.4 All load switches shall be rated at 20 AMPS.

429.3.3.4.5 Each load switch shall include three LED indicators on the face of the switch, visible through the door opening of the cabinet, and connected to the input functions.

429.3.3.5 SOLID STATE FLASHER

429.3.3.5.1 A solid state flasher, NEMA type 3, 20 amps per circuit, dual-circuit, shall be furnished with each controller cabinet. The flasher shall be rack-mounted in the back panel adjacent to the load bay. All solid state flashers shall conform to NEMA Standards.

429.3.3.5.2 The flasher transfer relays shall be the normally open, multi-contact plug type. A sufficient number of relays shall be provided to permit any combination of flashing red or yellow indications. One RC network shall be wired in parallel with each group of three flash transfer relays and any other relay coils. All flash transfer relay sockets shall be Cinch-Jones #2408SB or approved equal.

#### 429.3.3.6 CONFLICT MONITOR (NEMA Plus).

429.3.3.6.1 A conflict monitor unit shall be furnished with each controller. All signal monitors shall be the self-contained, shelf mounted type with the appropriate NEMA MS connector(s). In addition to this specification, all conflict monitors shall conform to NEMA Standards.

429.3.3.6.2 Minimum monitor functions shall be as follows:

429.3.3.6.2.1 Conflicting GREEN, YELLOW or WALK signal indications at the controller assembly field terminals.

429.3.3.6.2.2 Detect the absence of a required RED signal indication at the field terminal when the GREEN or YELLOW inputs of that channel are not active. The red

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monitor point shall be made on the field side of the field output terminal.

429.3.3.6.2.3 Monitor the operating voltage in the controller unit and the + 24 volt DC inputs.

429.3.3.6.2.4 Simultaneous sensing of active GREEN and YELLOW or GREEN and RED signal indications on a channel. If either of these conditions exist for 700 milliseconds, the conflict monitor shall not trigger. If either of these conditions exist for 1000 milliseconds, the conflict monitor shall trigger.

429.3.3.6.2.5 Absence of an active YELLOW input for a preset period (2.0 to 2.8 second range) following the termination of an active GREEN input on a channel.

429.3.3.6.2.6 In the event of any of the above faults, the monitor shall apply stop timing to the controller unit and transfer the signals to a flashing operation.

429.3.3.6.2.7 Green or Walk vs. Yellow. When enabled, all channels will monitor for Green or Walk indications on at the same time as the Yellow for that same channel.

429.3.3.6.2.8 Green, Walk or Yellow vs. Red. When enabled, the corresponding channel will monitor for Green, Walk or Yellow indications on with the Red indication of the channel.

429.3.3.6.3 Manual reset shall be required following a conflict or sequence failure, or absence of red; to place signals in normal operation. Return to normal operation shall be automatic after a power supply fault or power outage, following a preset period of flashing operation. Flashing operation shall not be returned to normal operation if a conflict has been detected prior to a power interruption.

429.3.3.6.4 A cabinet interlock shall be provided indicating the presence of the monitor and causing a transfer to flashing operation if the monitor is disconnected.

429.3.3.6.5 Monitor shall include a LCD readout display with the minimum indicators required as follows:

- a. Triggering of the conflict monitoring.
- b. Triggering of the RED monitoring.

- c. Triggering of the sequence monitoring.
- d. Triggering of the +24V monitor portion #1.
- e. Triggering of the +24V monitor portion #2.
- f. Triggering of the controller voltage monitor.
- g. One indicator per channel which displays an active GREEN, YELLOW or WALK input. This channel indicator shall latch with the triggering of the conflict monitor.
- h. A RED failure. The channel indicator(s) in fault shall illuminate.
- i. A sequence failure. The channel indicator(s) in fault shall illuminate.
- j. Green or Walk vs. Yellow.
- k. Green, Walk or Yellow vs. Red.

429.3.3.6.6 Monitor shall be capable of recording fault history and generating reports.

429.3.3.6.7 Type of monitor to be furnished:

CABINET TYPE	MONITOR TYPE
4 phase single ring	NEMA Plus 6 Channel
8 phase dual ring	NEMA Plus 12 Channel

429.3.4 If new traffic actuated controllers and controller cabinets are called for on plans, the CONTRACTOR shall provide controllers and cabinets made by the same manufacturer.

429.4 CONSTRUCTION REQUIREMENTS.

429.4.1 Traffic signal controller cabinets shall normally be installed on concrete bases in the location shown on the plans or as directed by the ENGINEER. The cabinet door shall face away from the street unless otherwise specified on the plans. Upon installation of a ground mounted controller cabinet, the necessary grout or caulking shall be placed between cabinet and concrete base to provide a weather-resistant, dust-tight installation.

429.4.2 Should the CONTRACTOR find it necessary at a certain traffic signal system installation to provide a controller cabinet which is to large to be mounted on the type mounting arrangement as shown on the plans, he

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shall immediately notify the ENGINEER that a mounting change is necessary. This notification shall be prior to the pouring of the base as shown on the plans. The CONTRACTOR shall provide the proper mounting hardware and mount the controller cabinet as directed by the ENGINEER.

429.4.3 No conduit entry shall be made into the side of the cabinet unless otherwise called for on the plans or approved by the ENGINEER.

#### 429.4.4 TESTING

429.4.4.1 The CONTRACTOR shall have the controllers and cabinets, and any specified auxiliary equipment transported to a location as directed by the ENGINEER with appropriate written documentation including project identification, signal plan sheets, operator manuals, and transmittal letter. These items will be delivered no less than 60 days prior to the ENGINEER's acceptance of compliance and the equipment will be tested for a minimum of 30 days of the 60 day period. The controller and cabinet furnished at this time shall be capable of operation with all load outputs and shall be complete in accordance with the plans, including any auxiliary equipment.

429.4.4.2 The controller may be subjected to inspection and testing as follows:

429.4.4.2.1 Visual inspection for compliance with contract requirements, arrangement of equipment, specified markings, and workmanship.

429.4.4.2.2 Operational Testing.

- 1. Specified phasing.
- 2. Various timings.
- 3. Indicators.
- 4. Pedestrian phasing.
- 5. Auxiliary functions and interconnects.
- 6. Flash mode.
- 7. All possible conflicts for fail safe.
- 8. Preemption interruption with every function and phase, when applicable.

- 9. Load switches at 1800 watts.
- 10. Interrupted power test.
- 11. Timings and operation at input voltage of 105 and 130 VAC.
- 12. Ambient temperature of 160 degrees  $F \pm 5$  degrees F for a maximum period of 14 days.

429.4.4.2.3 The controller will be deemed to have failed to comply with these specifications if, as a result of the above mentioned tests, its operation or component parts are affected in any manner.

429.4.4.2.4 In the event of a component failure all testing will be stopped, and the CONTRACTOR will be so notified. It will then be the CONTRACTOR's responsibility to provide for the disposition or repair of the controller. The CONTRACTOR may submit new or repaired equipment for testing, and the ENGINEER will determine the length of this new test period up to 30 days.

429.4.4.2.5 Upon notification of completion of the lab test and acceptance, the CONTRACTOR shall transport the controller and cabinet to the project site.

429.4.4.2.6 In addition to the lab tests, final acceptance of all controllers and cabinets shall occur as specified in Section 420 - General Clauses for Traffic Signal and Street Lighting Systems.

#### 429.4.5 TURN ON

429.4.5.1 The turn on of all controllers and auxiliary equipment after installation shall be made only after the entire signal system has been inspected and approved by the ENGINEER. The CONTRACTOR shall give the ENGINEER at least five (5) working days advanced written notice of the anticipated turn-on time. Personnel of the OWNER shall be present during turn on. The CONTRACTOR shall remove any conflicting traffic control signing as directed by the ENGINEER.

429.4.5.2 When called for on the plans, the CONTRACTOR shall arrange for a qualified manufacturer's representative to be present at the turn-on and/or to conduct a prepared school for new or special control equipment. The time and location shall be as specified on the plans.

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429.4.6 MODIFICATIONS: Modifications and/or added equipment to an existing cabinet shall be made by a qualified signal manufacturer's representative. Cabinet wiring diagrams will be as noted on the plans. The proposed modifications to these wiring diagrams shall be returned and approved by the ENGINEER before any cabinet modification work is started. All work shall be inspected by the ENGINEER or his delegated representative(s) before the system is re-energized.

429.4.7 REMOVE AND RESET SIGNAL CONTROLLER: Remove and Reset Signal Controller. The CONTRACTOR shall disconnect existing signal controller from the existing controller cabinet, relocate the controller to the location shown on the plans, and reinstall the controller in a new or used controller cabinet.

429.4.8 REMOVE AND RESET SIGNAL CONTROLLER CABINET: The CONTRACTOR shall construct new foundations for the signal controller cabinet. The CONTRACTOR shall then remove existing signal controller cabinet and relocate the signal controller cabinet to the new foundations. All field wiring including loop lead-in cables, power, pedestrian pushbuttons, and signals shall be reconnected to provide a complete and operational signal.

429.5 MEASUREMENT AND PAYMENT.

429.5.1 Traffic actuated controllers, system masters, four phase single ring controller cabinets, eight phase dual ring controller cabinets, including all associated auxiliary equipment, will be measured by the unit of each type specified, complete in place.

429.5.2 Removing and resetting signal controllers and cabinets will be measured by the unit of each type specified, complete in place.

429.5.3 The accepted quantities of traffic actuated controllers system masters, four phase single ring controller cabinets, eight phase duel ring controller cabinets and removing and resetting signal controllers and cabinets will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown on the bid proposal.

## REMOVAL OF TRAFFIC SIGNAL PRESSURE DETECTOR

#### 430.1 GENERAL

The work covered by this section consists of furnishing all labor, equipment, materials, and incidentals necessary for the removal and disposal of existing traffic signal pressure detectors and removal and replacement of pavement, as specified herein.

430.2 REFERENCES

430.2.1 ASTM

D 1557

430.2.2 This publication: SECTION 336 SECTION 343

## 430.3 MATERIALS

Replacement of pavement shall be with asphalt concrete as described in Section 336.

## 430.4 REMOVAL METHODS

430.4.1 Prior to removal CONTRACTOR shall verify with the OWNER that detector is inactive. Traffic signal pressure detectors shall be removed by means and methods such that no adjacent pavement to remain in place is damaged. At any intersection, only one detector on any leg shall be worked on at any one time.

430.4.2 Prior to removing the detector, the pavement shall be marked with smooth, horizontal lines a distance of six inches (6") around the perimeter of the concrete foundation. Then, the pavement shall be saw cut with a power saw along these lines to a depth sufficient to permit removal without damaging adjacent pavement. Any unnecessary irregular breaking caused by the CONTRACTOR shall be replaced at no additional expense to the OWNER. Any irregular breakage regardless of the cause shall be trimmed back as required by the ENGINEER. After the cut is made, the pavement shall be removed around the perimeter of the detector according to Section 343.

430.4.3 Existing conduit shall then be disconnected and the detector removed by whatever means necessary so that adjacent pavement remains undamaged.

#### 430.5 PAVEMENT REPLACEMENT

430.5.1 All loose and foreign material shall be removed and the base smoothed and compacted. Subbase material shall be placed and compacted to 95 percent of maximum density, as determined by ASTM D 1557. The top of the subbase material shall be 8 inches below the surface of the adjoining pavement.

430.5.2 If the adjacent pavement is asphaltic concrete, then the following procedure for pavement replacement shall apply. Asphalt tack coat shall then be applied. An asphalt concrete base course, 1500-lb. stability, shall be placed in maximum 4-inch lifts to within one and one-half inches of the surface of the adjacent pavement. A one and one-half inch asphalt concrete surface course, 1800-lb. stability, shall be placed over the base course to match the grade of the existing surface.

430.5.3 If the adjacent pavement is Portland cement concrete, pavement replacement shall meet the Standard Specifications for Portland Cement Concrete Pavement.

## 430.6 MEASUREMENT AND PAYMENT

The removal of pavement and pressure detector, disconnection of conduit, and placement of pavement materials, as specified shall be considered a complete construction item. Pay shall be made at the unit price per each detector, as specified in the Bid Proposal.

#### BEACONS AND SPECIAL SIGNAL EQUIPMENT

431.1 GENERAL. This work shall consist of furnishing and installing intersection control and hazard identification beacons and other specialized signal equipment in compliance with the specifications, details shown on the plans, and Standard Drawings at the location shown on the plans, or as established by the ENGINEER.

#### 431.2 REFERENCES.

- 431.2.1 American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications, Latest Edition
- M133 Preservative and Pressure Treatment Process for Timber
- 431.2.2 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition
- A123 Zinc Coating on Product Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Stripes
- 431.2.3 Manual on Uniform Traffic Control Devices (MUTCD), Latest Edition
- 431.2.4 National Electrical Code (NEC), Latest Edition
- 431.2.5 National Electric Manufacturers Association (NEMA) Standards, Latest Edition
- 431.2.6 This Publication, Latest Edition

#### SECTION 101 PORTLAND CEMENT CONCRETE SECTION 102 STEEL REINFORCEMENT

- SECTION 501 EXCAVATION AND BACKFILL FOR STRUCTURES
- SECTION 701 TRENCHING, EXCAVATION, AND BACKFILL

#### 431.3 MATERIALS.

431.3.1 BEACON ASSEMBLY: Beacon assemblies shall be single section, 12" lens, traffic signal assemblies in accordance to the requirements of Section 427 Signal Assemblies. Beacon assemblies shall normally display a flashing red or yellow indication as called for on the plans. Beacons shall be mounted on the specified support (Type I standard, sign support or span wire) as detailed on the plans. The mounting of beacons may be singly or in groups as required.

431.3.2 SPAN WIRE INSTALLATION: Span wire installments shall be a set of poles and guy wire support system over a roadway normally used for flashing beacons and temporary signals. Span wire installations shall include poles, guy wire, clamps, shackles, turnbuckles and all additional material listed on the plans.

431.3.2.1 POLES

431.3.2.1.1 Poles shall be free standing, steel strain poles, or timber poles capable of supporting the span and specified without noticeable bending.

431.3.2.1.1.1 STEEL STRAIN POLES: Strain poles shall be fabricated from round or octagonal, tapered steel tube of a length detailed on the plans and a wall thickness of 3 gauge (approx. 1/4 inch.) or thicker as required by the design span shown on the plans and an AASHTO 80 wind loading. The steel shall have a yield strength of 48,000 psi or greater. All strain poles shall be galvanized inside and out in accordance with ASTM A 123. The length and minimum top and bottom pole outer diameters shall be as called for on the plans.

431.3.2.1.1.2 TIMBER POLES: Timber poles shall be treated in accordance with the "equipments of AASHTO M-133. Poles shall be of the size called for on the plans and as a minimum shall be butt treated.

431.3.2.2 ANCHORS: The anchor base shall be designed to develop the maximum strength of the shaft. Anchor bolts shall be  $1\frac{1}{2}$ " diameter by 5'0" long with minimum tensile strength of 85,000 psi, or as called for on the plans. All anchor bolts shall be provided with two nuts and two washers each.

431.3.2.3 GUY STRAND WIRE: Guy strand wire (7wire) shall be provided with an approximate weight of 273 lbs. per 1,000 feet and a minimum braking strength of 10,000 lbs.

431.3.3 FLASHER CONTROLLER.

431.3.3.1 FLASHER

431.3.3.1.1 The flasher unit shall be an alternating two-circuit (115 VAC), solid state plug-in type with a 20

## BEACONS AND SPECIAL SIGNAL EQUIPMENT

amp or greater rating per circuit. The unit shall be designed to plug into a NEMA type.

431.3.3.1.2 All flasher units shall be fully solid state with no moving parts. The unit shall utilize zero voltage switching with 50 percent on-time and a flash rate of 50 to 60 per minute. All flasher units shall be designed to operate at full capability from -30F to +160F ambient temperature.

431.3.3.2 CABINET.

431.3.3.2.1 The cabinet shall be a sturdy, cast or sheet aluminum housing with a hinged main door equipped with a lock for a police key. Two police keys shall be furnished with each cabinet. The cabinet shall be at least 12 inches by 10 inches by 6 inches deep or as required to house the specified equipment. All switches and controls shall be accessible through the front door.

431.3.3.2.2 The cabinets shall be designed for side-ofpole mounting unless otherwise shown on the plans. Access to the cabinet shall be through a hole located in the bottom and top, drilled and threaded to accept a  $1\frac{1}{2}$ inch GRC conduit, or as detailed on the plans. All cabinets shall be finished in accordance with Section 429 - Traffic Signal Controllers.

431.3.3.2.3 All cabinet wiring shall be neat and firm. All wiring and harnesses shall be laced or bound together with Ty wrap or equivalent. All terminals shall be numbered and identified in accordance with a cabinet wiring diagram which shall be furnished by the supplier. The flasher cabinet shall include the following terminals, protection devices and switches:

- a. Terminal (barrier type) for 115 VAC power feed.
- b. Main power supply circuit breaker,, 15 amp. min. rating.
- c. Terminals (barrier type) for field conductor to beacons, one for each circuit.
- d. Signal shutdown switch, not affecting clock power.
- e. Copper ground strip, grounded to cabinet, for connection of all common conductors.
- f. Terminal (barrier type) for time switch opening and closing as required.

g. Radio line filter for filtering AC + power.

h. Lighting arrester for filtering lighting or high voltages to ground for protection of equipment.

431.3.3.2.4 When specified, the flasher controller shall include a time switch. The time switch shall be a weekly time clock, programmable for the on/off function at up to eight times a day and 40 times a week. The time clock shall have an available automatic daylight saving time correction. It shall be possible to vary or omit a day program. Programming shall be by keyboard and/or digital switches. Time of day and keyboard entered data shall be shown on an LED display. The clock shall have battery backup so that in the event of loss of AC power, time will be held a minimum of 48 hours at an accuracy of  $\pm 0.005\%$  or better. The time switch shall make it possible to turn the flashing field indications on or off on either a time of day basis or manually. The time clock unit shall be mounted on the back side of door.

# 431.4 CONSTRUCTION REQUIREMENTS.

431.4.1 Beacons and flasher controllers shall be mounted on the specified support as called for and detailed in the plans.

431.4.2 Installation of span wire poles including anchor bolts shall include the erection of poles as shown on the plans, installation of anchor bolts in a foundation, and leveling the pole. The foundation shall cure for a minimum of 7 days before the pole placement. Grout (4 inches minimum) shall be placed between anchor base and the top of the foundation after raking. The complete span wire shall be tensioned with the sag shown on the plans or as directed by the ENGINEER.

431.4.3 Required electrical cable shall be run inside the pole and extended through the top with standard weatherhead fittings if steel poles are used. Electrical cable shall be run inside galvanized rigid conduit along the outside of the pole if wooden poles are used.

431.4.4 When "temporary signal spans" for use during construction are called and there is not a signal controller available, the CONTRACTOR shall supply a signal controller.

431.4.5 When the plans call for temporary signal spans the CONTRACTOR shall remove the material on completion of the work. Temporary signal spans shall

#### BEACONS AND SPECIAL SIGNAL EQUIPMENT

remain the property of the CONTRACTOR after removal unless otherwise specified on the plans.

#### 431.5 MEASUREMENT AND PAYMENT.

431.5.1 Beacons and flasher controllers will be measured by the unit, complete in place.

431.5.2 Span wire installation will be measured by the lump sum including all items listed on the plans or as shown in the Standard Drawings complete in place.

431.5.3 Temporary Signal Spans will be measured by the lump sum including all items listed on the plans or as shown in the Standard Drawings, all adjustment work required during construction phases, and all electrical energy and maintenance costs, complete in place.

431.5.4 The accepted quantities of beacons, flasher controllers, signal spans, and temporary signal spans will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown on the bid proposal

## LUMINAIRES

432.1 GENERAL. This work shall consist of furnishing and installing luminaires on standards, bridge structures, or sign supports in compliance with the specifications, details shown on the plans, and Standard Drawings, at the locations shown on the plans, or as established by the ENGINEER.

432.2 REFERENCES.

431.2.1 American National Standards Institute (ANSI) Standards, Latest Edition

RP8 Roadway Lighting (IES)

432.3 MATERIALS.

432.3.1 STREET LIGHT LUMINAIRE.

432.3.1.1 Street light luminaires shall be horizontalburning cobra type with a 2-inch slipfitter on the house side for mounting on a Type V standard. The lamp type shall be LED. The lamp wattage and line voltage shall be as specified on the plans or in the special provisions. The required drivers shall be an integral part of the luminaire and shall be pre-wired to the lamp socket (may use quick disconnect plugs), requiring only connection to the power supply terminal (screw type).

432.3.1.2 Unless otherwise specified in the plans, all fixtures shall have full cutoff optics and shall have an ANSI/IES M-C-II distribution or as required by the roadway. Photometric data shall be submitted to the ENGINEER for approval.

432.3.1.3 The reflector shall be anodized aluminum, ALZAK, ALGLAS or approved equal treatment. The socket shall be of a high grade porcelain with both axial and vertical adjustment.

432.3.1.4 The driver shall be an easily removable power pack connected by a quick disconnect plug. The driver shall be accessed through a separate rear door not disturbing the sealed optical system, or through a single door, also accessing the optical system, when the driver is mounted to a tray that is removable without the use of tools.

432.3.1.5 The slipfitter shall provide positive clamping on 1-1/4 or 2" pipe bracket. It shall also permit leveling of the luminaire on the horizontal  $\pm 3$  degrees.

432.3.1.6 Luminaires with full cutoff distributions shall utilize a shielded optical system that incorporates a specially designed reflector and a heat and impact resistant flatglass lens. The luminaire shall allow no light above  $90^{\circ}$ .

432.3.1.7 An individual photocell controller on the top of the housing, mounted inside or outside, shall be provided when specified on the plans or special provisions.

432.3.1.8 All gaskets shall be composed of a material capable of withstanding the temperature involved and shall be securely held in place. The housing and refractor ring shall be of die-cast aluminum. The latch and exposed hinge parts shall be manufactured from noncorrosive material.

432.3.1.9 When mounted on Bridge Deck, the pole shall be mounted on a vibration dampening pad and the fixture shall have a lamp stabilizer to reduce the potential for damage to the fixtures from vibration. The fixture shall be certified to withstand a 3G vibration test.

432.3.1.10 AREA LUMINAIRE: Area luminaires shall be decorative type luminaires mounted on Type IV standards. The general appearance, color, and electrical requirements shall be as detailed in the special provisions and/or plans. Unless otherwise specified, the luminaire shall provide a symmetrical light distribution.

432.3.3 UNDERPASS LUMINAIRE

432.3.3.1 Underpass luminaires shall be designed to mount directly on a wall with surface wiring or over a recessed outlet box, in conformance with details on the plans. The luminaire may be mounted by a flush outlet box stud or by three mounting bolts. Underpass luminaires shall be weatherproof, self-contained units with an integral driver. The luminaire shall consist of a die cast aluminum base housing, Borosilicate Prismatic Glass Refractor, hinged lens assembly and have a quality gasket between the door and housing.

432.3.3.2 Lamps shall be LED.

432.3.3.3 Vandal protection shall be provided by either a cast aluminum grid guard or a Lexan shield over the refractor. The latches shall be tamper resistant.

## LUMINAIRES

432.3.3.4 The luminaire shall light an area one mounting height on either side of the fixture and two mounting heights in front.

### 432.3.3.5 DARK SKY COMPLIANCE

All fixtures shall comply with the IES dark sky compliance.

432.3.4 LED LAMPS

432.3.4.1

IESNA RP-8 guidelines are used for roadway illuminance.

LED Luminaires need to comply with the following table:

Roadway Type	Wattage Range (W)	Color Temperature (K)	Minimum Life Expectancy
Collector	70-135	3500/4000	100,000
Expressway	75-175	4000	100,000
Local	30-135	3000	100,000
Arterial	45-140	4000	100,000
Pedestrian	25-85	3000/3500/ 4000	60,000

#### **<u>ROAD TYPE</u> <u>ROAD TYPE EXAMPLES</u>**

COLLECTOR	MORRIS/OURAY
EXPRESSWAY	I-25/I-40
LOCAL	RESIDENTIAL STREETS
ARTERIAL	MENAUL/EUBANK/PASEO
PEDESTRIAN	DECORATIVE, ART, OLD TOWN

## \*HIGH MAST LIGHTING MAY EXCEED ABOVE VALUES

432.3.4.2 The median life expectancy value shall be based on LM80 standards.

432.5 CONSTRUCTION REQUIREMENTS.

432.5.1 The CONTRACTOR shall properly align and level all luminaires in accordance with the manufacturer's

432.5.2 The installation of luminaires shall include two single conductors, #10 or as specified on the plans, to the standard pole base or nearest splice point into main distribution feed.

432.5.2.1 The installation of underpass luminaires shall include all conduit and wiring to the nearest pull box (splice point into the main distribution feed) and all necessary mounting devices.

432.5.2.2 The above specified wiring, conduit, mounting hardware and switches shall be considered part of the luminaire installation and no separate payment will be made therefor.

# COLOR TEMPERATURE (K)

Ν

## 432.6 MEASUREMENT AND PAYMENT.

432.6.1 Luminaires will be measured by the unit, complete in place.

432.6.2 The accepted quantities of luminaires will be paid for at the contract unit price per unit of measurement for each of the pay items as shown on the bid proposal.

## RETROREFLECTORIZED PAINTED PAVEMENT MARKINGS

440.1 GENERAL: This work shall consist of furnishing and installing permanent and temporary retroreflectorized painted pavement markings in substantial compliance with the specifications and details shown on the plans, at the locations shown on the plans, or as established by the ENGINEER.

- 440.2 REFERENCES.
- 440.2.1 Manual on Uniform Traffic Control Devices (MUTCD), Latest Edition
- 440.3 MATERIALS.

440.3.1 TRAFFIC PAINT: Traffic paint shall conform to the requirements of the City of Albuquerque for White and Yellow Traffic Line Paints Used on Construction Projects (Combination Alkyd and Hypalon - Fast Dry Type).

440.3.2 REFLECTORIZED GLASS BEADS: Provide high performance beads for improved retroreflectivity and durability for roadway markings in accordance with the following bead retained percentage table:

U.S. Mesh	Microns	% Retained	
18	1000	5 - 15	
30	600 20 - 35		
50	300	55 - 75	
100	150 0 - 5		

Provide beads that are colorless/clear and free of carbon residue. Provide beads where all +20 US Mesh beads are 85% minimum rounds and overall rounds are 75% minimum. Use ASTM D 1155 test method for all beads except the +20 US Mesh which are inspected visually. Provide beads with an index of refraction minimum 1.51 by oil immersion method in accordance with ASTM D 1155. Provide beads with a resistance to acid, specifically when tested as specified in Federal Specification TT-B 1325C, 4.3.6; the beads shall not develop any surface haze or dulling. Provide beads with a resistance to calcium chloride, specifically when tested as specified in Federal Specification TT-B 1325C, 4.3.7, the beads shall not develop any surface haze or dulling. Provide beads with a resistance to sodium sulfide, specifically when tested as specified in Federal Specification TT-B 1325C, 4.3.8, the sodium sulfide solution shall not darken the beads. Provide beads with water resistance, specifically when tested as specified in Federal Specification TT-B 1325C, 4.3.9, the water shall not produce dulling or hazing of the beads, and not more than 4.5 ml of 0.1N hydrochloric acid shall be used for the titration. Provide beads with moisture resistant coating. Provide all post consumer and post industrial glass beads manufactured from North American glass waste streams. The bead manufacturer shall submit a notarized certification to the City that North American glass waste streams were used in the manufacture of product meeting this specification. Provide beads that are compatible with all binder systems, including alkyd and hydrocarbon thermoplastic, water and solvent based paint, epoxy, and methylmethacrylate. Provide glass beads furnished in bags identifying contents, manufacturer and net weight.

#### 440.3.3 TEMPORARY MARKING TAPE.

440.3.3.1 Temporary adhesive marking tape shall consist of weather and traffic resistant yellow or white retroreflective marking material and shall conform to the following requirements:

440.3.3.1.1DESCRIPTION: The adhesive pavement striping material shall consist of white or yellow retroreflective marking material on a conformable nonmetallic backing coated with a pressure sensitive adhesive and designed for marking of bituminous or Portland Cement Concrete surfaces.

440.3.3.1.2 COLOR: The color of the visible surface shall be either white or yellow in accordance with the MUTCD and shall closely match the color of the paint specified in this Section 440.

440.3.3.1.3 RETROREFLECTANCE: The white and yellow markings shall have the following initial minimum retro-reflectance values at 0.2 degree and 0.5 degree observation angles and 86 degrees entrance angle as measured in accordance with the testing procedure of Federal Test Method Standard 370 unless a higher value is specified on the plans.

TEMPORARY MARKING TAPE					
Minim um Retro-reflectivity					
(Millicandelas Per Footcandle Per Square Foot)					
O A	ΕA	W hite	Yellow		
0.2	86	1770	1310		
0.5	86	1270	820		

Where: OA = Observation Angle in Degrees EA = Entrance Angle in Degrees

440.3.3.1.4 ADHESION: The material shall have a precoated pressure sensitive adhesive which does not require a liner for protection from contamination, pre-adhesion, or blocking within the roll. Said material shall show no appreciable loss of adhesion after application. 440.3.3.1.5 CONFORMABILITY: The material shall be flexible and formable, shall show no cracking, flaking, or loss of reflective elements and, following application, shall remain conformed to the texture of the pavement surface.

440.3.3.1.6 PHYSICAL PROPERTIES.

440.3.3.1.6.1 DIMENSIONS: The thickness of the adhesive marking tape for normal use shall not be less than 10 mils and shall be provided in 4-inch or 6-inch width (plus or minus 1/16 inch) unless otherwise specified.

440.3.3.1.6.2 WEAR RESISTANCE: Wear resistance samples of the adhesive pavement striping material applied to standard specimen plates and tested in accordance with Federal Test Methods No. 141, Method 6192, using a CS-17 wheel and 1000 gram load shall not exhibit a significant change in color after 5000 cycles.

440.3.3.1.7 REMOVABLITLY.

440.3.3.1.7.1 Temporary adhesive pavement striping material shall be readily removable from the pavement by following the manufacturer's recommendations, unless otherwise specified.

440.3.3.1.7.2 Removal shall not require sandblasting, solvent or grinding methods and shall not result in objectionable staining of the pavement surface.

440.3.3.1.8 DURABILITY: The material shall be weather resistant and show no appreciable fading, lifting, or shrinkage.

440.3.3.1.9 GENERAL

440.3.3.1.9.1 The materials as supplied shall be of good appearance and free from cracks, and the edge shall be true, straight, and unbroken.

440.3.3.1.9.2 The adhesive pavement striping material shall be packaged in accordance with accepted commercial standards, shall be stored at temperatures not to exceed 100 degrees Fahrenheit under normal conditions, and shall be suitable for use for a period of at least one (1) year after purchase.

440.3.4 ACCEPTANCE: Acceptance of traffic paint and temporary marking tape will be based upon receipt of certificates of compliance and documentation that the batch of paint and/or marking tape to be used has been tested by an independent laboratory and conforms with specifications.

#### 440.4 CONSTRUCTION REQUIREMENTS.

440.4.1 GENERAL

440.4.1.1 The traffic paint and beads shall be placed on the pavement by a spray type, self-propelled pavement marking machine, except that temporary striping during construction may be placed with other equipment designed for application of paint, or beads.

440.4.1.1.1 The machine shall be capable of applying a clear-cut 4-inch line or lines.

440.4.1.1.2 The machine shall be equipped with a mechanical device capable of placing a broken retro-reflective centerline with a 10-foot painted segment and a 30-foot gap.

440.4.1.1.3 The machine shall be equipped with an airoperated glass bead drop-in dispenser controlled by a spray gun mechanism.

440.4.1.1.3.1 The dispenser shall be capable of placing the glass beads (sphere shape) into the paint line as the paint is applied to the pavement in such a manner as to provide satisfactory marking and delineation.

440.4.1.1.4 The volume of paint and glass beads in place shall be measured by the quantity per mile method. The CONTRACTOR shall provide certification of the volume of the paint and bead tanks. The CONTRACTOR shall strap the tanks prior to beginning striping operation and again after a mile has been striped. As an alternative, the CONTRACTOR may externally mark the tanks indicating a volume equivalent to the tolerances shown in this Section 440 or have a calibrated rod marked with the equivalent volumes. The volumes shall be measured after a mile has been striped. At the option of the ENGINEER, if the striping machine is equipped with air atomized spray units, (not airless), and paint and bead gauges, the volume may be determined by utilizing said gauges.

440.4.1.1.4.1 The CONTRACTOR shall be required to restripe the roadway if 50% of the paint or beads are not placed on the roadway or if the ENGINEER determines that the striping is not adhering to the pavement or the glass beads are not adhering to the paint.

440.4.1.1.5 When paint has settled excessively, the CONTRACTOR shall re-disperse the settled pigments at the bottom of the paint drums, with a mixing device, prior to pumping or loading paint into the striping unit so excess pigments are not left on the bottom of the paint drum. Thinner shall not be allowed to be pumped into the paint tanks. If the CONTRACTOR uses thinner to clean his equipment, the CONTRACTOR shall be responsible for disposing of all debris including, but not limited to,

thinner at disposal sites approved by government agencies regulating the disposal of such materials.

440.4.1.1.6 Hot retroreflective thermoplastic pavement markings will be considered by Traffic Engineering Operations Division as a substitute for cold plastic, provided that installation is carried out per the manufacturer's specifications. Hot thermoplastic shall be a minimum of 90 mil thickness for lane lines and 125 mil for transverse lines. Ten (10) pound drop-on glass beads per 100 sq. ft. is required. All markings shall be alkyd thermoplastic.

440.4.2 PLACEMENT OF BEADS AND TRAFFIC PAINT

440.4.2.1 Retro-reflectorized painted markings for temporary use on final surfacing is prohibited. Pavement markings shall be applied during daylight hours when the pavement surface is dry and the weather is not foggy, rainy, excessively windy, or otherwise adverse to the application of markings. The surface shall be free from excess asphalt or other deleterious substances before traffic paint or beads are applied. The CONTRACTOR shall remove dirt, debris, grease, motor oils, rocks, or chips from the pavement surface before applying markings.

440.4.2.2 The CONTRACTOR shall provide the necessary personnel and equipment to divert traffic from the installation area where the work is in progress and during drying time. The CONTRACTOR shall submit a traffic control plan to the City's Construction Coordination Division for approval prior to the commencement of work. All damage to the pavement marking due to the CONTRACTOR's negligence or failure to maintain traffic control shall be repaired at the CONTRACTOR's expense.

440.4.2.3 Permanent retroreflectorized painted markings shall consist of two applications of markings. For painted markings on new pavement the second application of markings shall be placed no sooner than twenty-one days after placement of the first application of markings as directed by the ENGINEER.

440.4.2.4 Permanent retroreflective hot thermoplastic pavement markings shall be a minimum of 90 mil thickness for lane lines and 125 mil for transverse lines, or as directed by the ENGINEER. Ten pound drop-on glass beads per 100 sq. ft. is required. All markings shall be alkyd thermoplastic.

440.4.2.5 If paint is not adhering to the pavement, or if the glass beads are not adhering to the paint, or if the second application of pavement markings are not placed over the first application of markings in accordance with this Section 440, the CONTRACTOR will be required to remove the striping, and to restripe the roadway.

440.4.3 TOLARANCE FOR PLACING PAINT & BEADS

440.4.3.1 The finished line shall be smooth, aesthetically acceptable and free from undue waviness.

440.4.3.2 Painted lines shall be 4, 6, 8, or 12 inches wide as shown on the plans with a tolerance of plus or minus 1/8 inch and shall be placed at a minimum rate of 19.75 gallons of paint per mile for a solid 4-inch line and 4.94 gallons per mile for a broken 4-inch line, based on a 10foot stripe and a 30-foot gap (40-foot cycle). Other widths of striping shall be applied at the minimum rate that is the equivalent multiple of the above.

440.4.3.3 The length of the painted segment including the gap shall not vary more than six (6) inches in a 40-foot cycle.

440.4.3.4 The following transverse gap dimension between centerline stripes for two (2) and three (3) stripe combinations reflect a three (3) paint gun set up on the striping unit. The broken line shall be placed on the centerline of the roadway with the respective left and right no passing zones placed so a two (2) inch gap exists between the broken and solid no passing zone stripe. There shall be an eight (8) inch gap between the solid double yellow markings for no passing zones.

440.4.3.5 Glass retroreflectorizing beads shall be applied on the wet paint at a minimum rate of six (6) pounds to each gallon of paint. This translates into a minimum weight of beads of 29.6 lbs. per mile of broken line and 118.5 lbs. per mile of solid line. For other widths of striping, glass bead rate shall be applied at the minimum rate that is the equivalent multiple of the above.

# 440.4.4 PLACING TEMPORARY ADHESIVE MARKING TAPE

440.4.4.1 Adhesive tape marking material shall be applied as follows:

440.4.4.1.1 The CONTRACTOR shall provide the necessary personnel and equipment to warn and divert traffic during installation and removal from the area where the work is in progress as approved by the ENGINEER.

The surface to which the tape is applied shall be dry and free of oils, grease, dust, dirt and other deleterious substances and shall be primed with a primer material which is recommended by the manufacturer of the tape. 440.4.4.1.2 The tape shall be rolled or tamped down immediately after application until it adheres properly and conforms to the surface of the pavement in accordance with the manufactures recommendation.

440.4.4.1.3 Where striping is continuous, there shall be no more than three (3) splices per 120-feet of length.

## 440.4.5 REMOVAL OF TEMPORARY PAVEMENT MARKINGS

440.4.5.1 TEMPORARY ADHESIVE MARKING TAPE: All temporary pavement markings placed on the final pavement surface shall be removed by the CONTRACTOR when such temporary pavement markings are no longer required for traffic control as determined by the ENGINEER. Where temporary pavement markings, which are to be removed, consist of adhesive marking tape, the removal shall be complete with no segments or pieces of tape remaining on the pavement. The use of non-reflective black adhesive marking tape to obliterate temporary pavement markings will not be permitted. Over painting is not an acceptable method.

440.4.5.2 REFLECTORIZED PAINTED MARKINGS: Reflectorized painted markings for temporary use on final surfacing is prohibited. Reflectorized painted markings when used for temporary pavement markings shall be removed where required by traffic control plan in accordance with the provisions of Section 443 – Pavement Marking Removal.

440.4.6 COMPLIANCE WITH THE MUTCD: All retro reflectorized painted markings and temporary adhesive marking tape shall conform to the latest version of the Manual on Uniform Traffic Control Devices (MUTCD).

#### 440.5 MEASUREMENT AND PAYMENT

440.5.1 Retroreflective painted markings and hot retroreflective thermoplastic pavement markings shall be measured by the linear foot of either 4-inch, 6-inch, 8-inch, 12-inch, or 24-inch width, complete in place.

440.5.2 Temporary adhesive marking tape will be measured by the linear foot of 4-inch width, complete in place.

440.5.3 Removal of adhesive marking tape will not be measured.

440.5.4 Removal of retroreflectorized painted markings and hot retroreflective thermoplastic pavement markings will be measured by the linear foot of 4-inch

width, complete in place, in accordance with the provisions of Section 443 Pavement Marking Removal.

440.5.5 The accepted quantities of retroreflectorized painted markings and temporary adhesive marking tape will be paid for at the contract unit price per unit of measurement for each of the pay items as shown on the bid proposal. The removal of retro-reflectorized painted markings will be paid in accordance with the provisions of Section 443 Pavement Marking Removal.

# RETROREFLECTIVE PREFORMED PLASTIC PAVEMENT MARKINGS

441.1 GENERAL: This work shall consist of furnishing and installing retroreflective preformed plastic pavement symbols, legends, stripes and markings in compliance with the specifications and the details shown on the plans at the locations shown on the plans, or as established by the ENGINEER.

441.2 REFERENCES.

441.2.1 American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications, Latest Edition.

441.2.2 American Society for Testing and Materials (ASTM), Latest Edition.

441.2.3 Manual of Uniform Traffic Control Devices (MUTCD), Latest Edition

441.3 MATERIALS.

## 441.3.1 RETROREFLECTIVE PREFORMED PLASTIC PAVEMENT MARKINGS MATERIAL

441.3.1.1 Retroreflective preformed plastic pavement marking material shall consist of white or yellow weather resistant reflective film conforming to the requirements set forth herein. The material shall be manufactured and packaged in such a manner as to permit storage at normal shelf temperature for a period of not less than two (2) years from date of purchase. Prefabricated legends and symbols shall conform to the applicable shapes, sizes, and color as outlined in the latest edition of the Manual on Uniform Traffic Control Devices.

441.3.1.1.1 COMPOSITION: The retroreflective preformed plastic markings shall consist of high quality plastic materials, pigments, and 1.5 index glass beads uniformly distributed throughout their cross-sectional area, with a reflective layer of beads embedded in the top surface. Materials will be furnished with the appropriate adhesive system recommended by the manufacturer for successful installation.

441.3.1.1.2 SKID RESISTANCE: The surface of the retroreflective preformed plastic marking material shall provide a minimum skid resistance value of 50 BPN when tested according to ASTM E 303-667.

441.3.1.1.3 COLOR: The retroreflective preformed plastic marking material shall be white or yellow in accordance with the MUTCD unless otherwise specified.

441.3.1.1.4 THICKNESS: The thickness of the retroreflective preformed plastic marking material without adhesive shall be 60 mils (0.06 inches).

## 441.3.1.1.5 DURABILITY AND WEAR

RESISTANCE: The retroreflective preformed plastic pavement marking material, when properly applied, shall provide a neat, durable marking. The preformed plastic marking material shall provide a cushioned resilient substrate that reduces bead crushing and loss. The film shall be weather resistant and, through normal traffic wear, shall show no appreciable fading, lifting, or shrinkage within three years after installation, and shall show no significant tearing, rollback, or other signs of poor adhesion.

441.3.1.1.6 CONFORMABILITY AND RESEALING: The retroreflective preformed plastic marking material shall be capable of conforming to pavement contours, breaks, faults, etc., through the action of traffic at normal pavement temperatures. The film shall have resealing characteristics such that it is capable of fusing with itself and previously applied marking film of the same composition under normal conditions of use.

441.3.1.1.7 TENSILE STRENGTH: Retroreflective preformed plastic marking material shall have a minimum tensile strength of 40 pounds per square inch of cross section when tested according to ASTM D 638. A test specimen six (6) inches by one (1) inch by 0.06 inch minimum thickness shall be tested at a temperature range of 70 to 80 degrees Fahrenheit, using a jaw speed of 0.25 inch per minute.

441.3.1.1.8 ELONGATION: Retroreflective preformed plastic marking material shall have a minimum elongation of 50% when tested in accordance with ASTM D 638.

441.3.1.1.9 PLASTIC PULL TEST: Retroreflective preformed plastic marking material shall support a dead weight of four (4) pounds for not less than five (5) minutes at a temperature range of 70 to 80 degrees Fahrenheit. Test specimen size shall be six (6) inches by one (1) inch by 0.06 inch minimum thickness.

441.3.1.1.10 PIGMENTATION: The pigment for retroreflective preformed plastic marking material shall be selected and blended to provide a plastic which is white or yellow, conforming to the MUTCD through the expected life of the pavement marking plastic.

# 441.3.1.1.11 GLASS BEADS

441.3.1.11.1 Provide high performance beads for improved retroreflectivity and durability for roadway
markings in accordance with the following bead retained percentage table:

U.S. Mesh	Microns	% Retained			
18	1000	5 - 15			
30	600	20 - 35			
50	300	55 - 75			
100	150	0 - 5			

Provide beads that are colorless/clear and free of carbon residue. Provide beads where all +20 US Mesh beads are 85% minimum rounds and overall rounds are 75% minimum. Use ASTM D 1155 test method for all beads except the +20 US Mesh which are inspected visually. Provide beads with an index of refraction minimum 1.51 by oil immersion method in accordance with ASTM D 1155. Provide beads with a resistance to acid, specifically when tested as specified in Federal Specification TT-B 1325C, 4.3.6; the beads shall not develop any surface haze or dulling. Provide beads with a resistance to calcium chloride, specifically when tested as specified in Federal Specification TT-B 1325C, 4.3.7, the beads shall not develop any surface haze or dulling. Provide beads with a resistance to sodium sulfide, specifically when tested as specified in Federal Specification TT-B 1325C, 4.3.8, the sodium sulfide solution shall not darken the beads. Provide beads with water resistance, specifically when tested as specified in Federal Specification TT-B 1325C, 4.3.9, the water shall not produce dulling or hazing of the beads, and not more than 4.5 ml of 0.1N hydrochloric acid shall be used for the titration. Provide beads with moisture resistant coating. Provide all post consumer and post industrial glass beads manufactured from North American glass waste streams. The bead manufacturer shall submit a notarized certification to the City that North American glass waste streams were used in the manufacture of product meeting this specification. Provide beads that are compatible with all binder systems, including alkyd and hydrocarbon thermoplastic, water and solvent based paint, epoxy, and methylmethacrylate. Provide glass beads furnished in bags identifying contents, manufacturer and net weight.

441.3.2 ACCEPTANCE: Acceptance of retroreflective preformed plastic pavement marking material will be based upon receipt of certificates of compliance and documentation that the material has been tested by an independent laboratory and conforms to specifications.

#### 441.4 CONSTRUCTION REQUIREMENTS

441.4.1 The retroreflective preformed plastic pavement symbols, legends, stripes and marking shall be applied to the asphalt and/or portland cement concrete pavement at

the locations shown on the plans or as designated by the ENGINEER.

441.4.2 The asphalt and/or portland cement concrete pavement surface shall be clean and free of moisture, soil or other deleterious substances. A brooming or compressed air method shall be utilized to clean the pavement surface.

441.4.3 If inlayed material is required in the plans, the reflectorized plastic marker material shall be applied to the roadway surface following the placement of bituminous pavement and before final rolling is completed at the locations shown on the plans or as designated by the ENGINEER.

441.4.4 The use of hot retroreflective thermoplastic is prohibited for pavement markings; only preformed plastic shall be used.

441.4.5 CONTRACTOR shall remove all conflicting existing pavement markings.

441.4.6 When designated the on plans, the CONTRACTOR shall provide temporary lane delineation by placing a twelve (12) inch long strip of four (4) inch wide plastic temporary lane marking, forty (40) feet on center, on each new lift of asphalt surfacing including temporary asphalt connections, asphalt treated base course, asphaltic concrete base course, and asphaltic concrete surface course to cover a lapse in time before the final surfacing course and final striping is placed. After final striping is placed, any temporary lane lines remaining on the final surface course shall be removed.

441.4.7 COMPLIANCE WITH THE MUTCD: All retroreflective preformed plastic pavement markings shall conform to the Manual on Uniform Traffic Control Devices.

441.5 MEASUREMENT AND PAYMENT.

441.5.1 The retroreflective preformed plastic pavement stripes shall be measured by the linear foot of either 4-inch, 6-inch, 8-inch, 12-inch, or 24-inch width, complete in place.

441.5.2 The retroreflective preformed plastic pavement continental cross walks will be measured by the linear foot of 24-inch width, complete in place.

441.5.3 The retroreflective preformed plastic pavement stop bars will be measured by the linear foot of 12-inch or 24-inch width, complete in place. 441.5.4 The retroreflective preformed plastic pavement symbols, legends and markings will be measured per unit, complete in place.

441.5.5 The retroreflective preformed plastic pavement temporary lane lines will be measured by the linear foot of 4-inch width, complete in place.

441.5.6 The accepted quantities of retroreflective preformed plastic pavement stripes, stop bars, symbols, legends and temporary lane lines will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown on the bid proposal

#### HOT THERMOPLASTIC PAVEMENT MARKINGS

442.1 GENERAL: This work shall consist of cleaning and preparing pavement surfaces and furnishing and applying either white or yellow thermoplastic reflectorized pavement markings using extrusion, ribbon or spray dispensing devices of the required shape and thickness to the prepared pavement surface at the locations and in accordance with the details shown on the project plans, the manufacturer's specifications, and the requirements of these specifications, or as established by the ENGINEER.

#### 442.2 REFERENCES.

- 442.2.1 American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications, Latest Edition.
- 442.2.2 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition.
- 442.2.3 Manual on Uniform Traffic Control Devices (MUTCD), Latest Edition.
- 442.2.4 Federal Test Method Standards, Latest Edition.
- 442.2.5 New Mexico Department of Transportation Standard Specifications for Highway and Bridge Construction, Latest Edition.

#### 442.3 MATERIALS.

442.3.1 GENERAL **REOUIREMENTS:** The thermoplastic reflectorized material shall consist of a solid mixture of heat-stable resins, white or yellow pigment, inter-mixed glass beads, filler, and other materials in granular or block form specifically compounded for reflectorized pavement markings to be applied to the pavement in a molten state. The characteristics of the liquefied material shall be such that complete and even coverage of specified areas to the required thicknesses is provided by the required application method and rate. Upon cooling to normal pavement temperature, this material shall produce an adherent reflectorized marking capable of resisting deformation and wear in the roadway.

442.3.2 COMPOSITION: The ingredients of the thermoplastic composition shall be thoroughly mixed and in a solid or sectionalized block, or free-flowing granular form. When heated in a melting apparatus, the material shall readily liquefy into a uniform solution. This solution shall be free from all skins, dirt, foreign objects or any other ingredient which would cause bleeding, staining, blotting, or discoloration when applied to the bituminous or concrete pavement surfaces. The thermoplastic composition shall conform to the following requirements:

	Percent by Weight			
	White	Yellow		
Binder	20%	20% min		
Billder	min			
Titanium dioxide (for white)	10%			
Thankum dioxide (for white)	min	-		
Yellow lead-free pigment (for		1.5%		
yellow)	-	min		
Reflective glass inter-mix beads	30-45%	30-45%		
Calcium carbonate or equivalent filler	20- 42%	20- 42%		

442.3.2.1 BINDER COMPOSITION: The thermoplastic shall be based on the following binder composition:

442.3.2.1.1 Alkyd shall consist of a mixture of synthetic resins, at least one of which is solid at room temperature, and of high-boiling-point plasticizers. At least one third of the binder composition and no less than eight percent by weight of the entire material formulation shall be solid maleic-modified glycerol ester resin or maleic modified pentaerythritol ester resin. The alkyd binder shall not contain any petroleum-based hydrocarbon resins.

442.3.2.1.2 An alkyd thermoplastic formulation may be used for symbols, legends, and transverse lines, including stop bars and crosswalks.

442.3.2.1.3 An alkyd thermoplastic formulation may be used for longitudinal lines, including lane lines and edge lines, unless otherwise shown on the project plans or specified herein. Extrusion or spray formulations shall be used in accordance with requirements of the application equipment used to install the markings.

# 442.3.2.2 REFLECTIVE GLASS BEADS.

442.3.2.2.1 The inter-mix glass beads shall conform to AASHTO M 247 Type I, and may be coated or uncoated as recommended by the manufacturer. If uncoated beads are used, the thermoplastic formulation shall be configured to minimize settling of the intermix beads when the material is heated and applied.

442.3.2.2. In addition to incorporating glass beads in the thermoplastic mix, glass beads shall be applied to the surface of the molten material immediately after application. The drop-on beads shall be in accordance with New Mexico Department of Transportation Standard Specifications for Highway and Bridge Construction section 704.2.2 and shall be applied at a minimum rate of 10 pounds of glass beads per 100 square feet of line (300 linear feet of four inch stripe).

442.3.2.3 FILLER: The filler shall be a white calcium carbonate or equivalent filler with a compressive strength of at least 5,000 pounds per square inch.

442.3.2.4 TITANIUM DIOXIDE: Titanium Dioxide shall conform to the requirements of ASTM D 476 for Type II (92 percent).

442.3.2.5 YELLOW PIGMENT: The yellow pigment shall be heat resistant and lead free. The type of yellow pigment shall be the manufacturer's option provided that the material conforms to all color requirements in a stable and durable fashion as specified herein.

442.3.3 PHYSICAL CHARACTERISTICS OF THE COMPOSITION.

442.3.3.1 GENERAL REQUIREMENTS: The thermoplastic material shall not exude fumes which are toxic, injurious, or require specialized breathing apparatus when heated to the temperature range specified by the manufacturer for application. The material shall remain stable when held for four hours at this temperature, or when subjected to four re-heatings, not exceeding a total of four hours, after cooling to ambient temperature. The temperature viscosity characteristics of the plastic material shall remain constant throughout the re-heatings and shall show like characteristics from batch to batch. There shall be no obvious change in color of the

thermoplastic material as a result of reheating, and the color of the material shall not vary from batch to batch.

442.3.3.2 COLOR: The thermoplastic material, after heating for four hours  $\pm$  five minutes at 425°  $\pm$  3°F and cooled to 77°  $\pm$  3°F, shall meet the following:

442.3.3.2.1 White: Daylight reflectance at 45 degrees - 0 degrees shall be 70% minimum. Color shall match Federal Test Standard Number 595, color chip no. 17925.

442.3.3.2.2 Yellow: Daylight reflectance at 45 degrees - 0 degrees shall be 43% minimum. Color shall match Federal Test Standard Number 595, color chip no. 13538.

442.3.3.3 RETROREFLECTANCE: The white and yellow thermoplastic materials shall have the following minimum retroreflectance values at 86.5 degrees illumination angle and 1.5 degrees observation angle as measured by a Mirolux 12 portable retroreflectometer or similar approved device within 30 days after application to the roadway surface:

Product	Retroreflectance (millicandelas)				
White	300				
Yellow	200				

442.3.3.4 SOFTENING POINT: After heating the thermoplastic material for four hours  $\pm$  five minutes at 425°  $\pm$  3°F and testing in accordance with ASTM D 36, the materials shall have a softening point of 215°  $\pm$  15°F.

442.3.3.5 WATER ABSORPTION AND SPECIFIC GRAVITY: The thermoplastic material shall not exceed 0.5 percent by weight of retained water when tested in accordance with the requirements of ASTM D 570. The specific gravity of the material, as determined by Section 16 of AASHTO T 250, shall be between 1.85 and 2.15.

442.3.3.6 IMPACT RESISTANCE: After heating the thermoplastic material for four hours  $\pm$  five minutes at 425°  $\pm$  3°F and forming test specimens, the impact resistance shall be not less than 10 inch-pounds when tested in accordance with Section 9 of AASHTO T 250.

442.3.3.7 BOND STRENGTH: After heating the thermoplastic material for four hours  $\pm$  five minutes at 425°  $\pm$  3°F, the bond strength to Portland cement concrete shall be not less than 180 pounds per square inch. The

bond strength shall be determined in accordance with the procedures specified in Section 7 of AASHTO T 250.

442.3.3.8 ABRASION RESISTANCE: The abrasion resistance of the thermoplastic material shall be determined by forming a representative lot of the material at a thickness of 0.125 inches on a four-inch square monel panel (thickness  $0,050 \pm 0.001$  inches), on which a suitable primer has been previously applied, and subjecting it to 200 revolutions on a Taber Abraser at 25°C, using H-22 calibrated wheels weighted to 250 grams. The wearing surface shall be kept wet with distilled water throughout the test. The maximum loss of thermoplastic material shall be 0.5 grams.

442.3.3.9 CRACKING RESISTANCE AT LOW TEMPERATURE: After heating the thermoplastic material for four hours  $\pm$  five minutes at 425°  $\pm$  3°F, applying to concrete blocks, and cooling to 15°  $\pm$  3°F, the material shall show no cracks when observed from a distance exceeding 12 inches. Testing for low temperature crack resistance shall be in accordance with the procedures specified in Section 8 of AASHTO T 250.

442.3.3.10 FLOWABILITY: After heating the thermoplastic material for four hours  $\pm$  five minutes at 425°  $\pm$  3°F, and testing for flowability in accordance with Section 6 of AASHTO T 250, the white thermoplastic shall have a maximum percent residue of 18, and the yellow thermoplastic shall have maximum percent residue of 21.

442.3.3.11 YELLOWNESS INDEX: When tested per AASHTO T250 Section 4, the white thermoplastic material shall not exceed a yellowness index of 0.10. 442.3.3.12 FLOWABILITY (EXTENDED HEATING): After heating the thermoplastic material for eight  $\pm$  1/2 hours at 425°  $\pm$  3°F, with stirring the last six hours, and testing for flowability in accordance with Section 12 of AASHTO T 250, the thermoplastic shall have a maximum percent residue of 28.

442.3.3.13 FLASH POINT: The thermoplastic material shall have a flash point not less than 475°F when tested in accordance with the requirements of ASTM D92.

442.3.3.14 STORAGE LIFE: The materials shall meet the requirements of this specification for a period of one year from the date of manufacture. The month and year of manufacture shall be clearly marked on all packages of thermoplastic material. The thermoplastic material must also melt uniformly with no evidence of skins or unmelted particles for this one year period. Any material which does not meet the above requirements, or which is no longer within this one year period at the time of application, shall not be used. The contractor shall replace any outdated material with material meeting the above performance and time requirements at no additional cost to the Department.

442.3.3.15 PRIMER-SEALER: Primer-sealers shall be used on Portland cement concrete, or existing hot mix

asphaltic concrete surfaces prior to application of the thermoplastic material, and shall be applied as recommended by the thermoplastic material manufacturer. The primer-sealer shall be compounded specifically for use with the specified thermoplastic material. Application of primer-sealer will not be required on newly placed hot-mix asphaltic concrete surfaces prior to application of the thermoplastic material.

442.3.3.16 COLOR STABILITY: Using accelerated weathering per ASTM G155 cycle 1, white color stability shall be measured for no color change after 500 hours of exposure, and for yellow color shall be measured for no color change after 1000 hours of exposure.

442.3.4 PHYSICAL REQUIREMENTS FOR GLASS BEADS: Drop-on beads shall conform to the requirements of New Mexico Department of Transportation Standard Specifications for Highway and Bridge Construction Section 704.2.2. If recommended by the manufacturer, the drop-on beads shall have an adherence coating.

442.3.5 QUANTITATIVE REQUIREMENTS OF MIXED PAINT: The paints shall meet the quantitative requirements specified below:

PARAMETERS	White Alkyd Thermoplastic	Yellow Alkyd Thermoplastic		
Glass Bead Content, % bw	30% - 45%	30% - 45%		
Binder Content, % bw	20% minimum	20% minimum		
Calcium Carbonate, % bw	20% - 42%	20% - 42%		
Titanium Dioxide, % bw	10% minimum	N/A		
Organic Yellow Lead Free, % bw	N/A	1.5% minimum		
Softening Point (ASTM E 28)	194°F	194°F		
Temperature vs. viscosity characteristics, up to 4 reheatings to 401°F	Constant	Constant		
Specific Gravity max	2.15	2.15		
Bond Strength(psi) minimum ASTM D 4796 to unprimed portland				
cement,125 mils at 218°C, test at $25 \pm 2^{\circ}$ C	180 psi	180 psi		
Brookfield thermocel viscosity (spindle # 27,20RPM@ 425°F),	 			
poise	l			
Low Viscosity	<40	<40		
Extruded Viscosity	45 to 100	45 to 100		
Impact Resistance (inch-pound), ASTM D 2794	>50 in-lb	> 50 in-lb		
Hardness Shore A-2 Durometer	45 to 75	45 to 75		
Color CIE, Brightness Y	Min. 80	45 - 60		
Abrasion, max total weight loss, grams	4 to 12 g	4 to 12 g		
Test Distance $= 5$ in	l			
Blast Pressure = 40 psi	l			
Sample Angle = $10^{\circ}$	l			
Blast Media = 1200 grams	l			
Initial Retroreflectivity, min	250	175		

#### 442.4 CONSTRUCTION REQUIREMENTS.

#### 442.4.1 INSTALLATION.

442.4.1.1 MOISTURE: All surfaces shall be inspected for moisture content prior to application of thermoplastic. Approximately two square feet of a clear plastic of tarpaper shall be laid on the road surface and held in place for 15 to 20 minutes. The underside of the plastic or tarpaper shall then be inspected for a build up of condensed moisture from the road surface. If the amount of condensed moisture is of a sufficient amount to result in water dripping from the plastic or tarpaper when held in a vertical position, thermoplastic shall not be applied. This moisture test shall be repeated until the moisture in the road surface has been allowed to evaporate to a level whereby there is not excessive build up of condensed moisture on the underside of the plastic or tarpaper.

CLEANING: All surfaces shall be clean 442.4.1.2 and dry before thermoplastic can be applied. Loose dirt and debris shall be removed by blowing compressed air over the area to be striped. If the thermoplastic is to be applied over existing paint lines, the paint line shall be swept with a mechanical sweeper or wire brush to remove poorly adhered paint and dirt that would interfere with the proper bonding of the thermoplastic. Curing compound and loosely adhered surface film shall be removed from all new Portland cement concrete surfaces by loose grain abrasive pressure blasting or wire brushing. All dust and grinding debris must be removed completely before applying the primer. Open graded roadways (i.e., double bituminous surface treatment) require brooming to ensure cleanliness.

442.4.1.3 LAYOUT: The pavement markings shall be placed in proper alignment with guidelines established on the roadway. Deviation from the alignment established shall not exceed two inches per 200 feet of roadway nor shall any deviation be abrupt. Longitudinal markings shall be offset at least two inches from construction joints of Portland cement concrete surfaces and joints and shoulder breaks of asphalt surfaces.

442.4.1.4 PRIMER APPLICATION: When required, the primer shall be applied to the road surface in a continuous film at a thickness of 15 mils, plus or minus 2 mils. Before the thermoplastic is applied, the primer shall be allowed to dry to a tacky state. The thermoplastic shall be applied within two hours after the primer application.

442.4.1.5 AMBIENT CONDITIONS: The ambient air and road surface shall be 50°F and rising before application of thermoplastic can begin.

442.4.1.6 MATERIAL REQUIREMENTS: The pavement marking material shall be installed in a molten state by the conventional extrusion or ribbon extrusion method at a minimum temperature of 400°F and a maximum temperature of 450°F. Scorching or discoloration of material shall be cause for rejection by the ENGINEER. The machinery shall be constructed so that all mixing and conveying parts, up to and including the extrusion die, maintain the material in the molten state, at the required application temperature.

442.4.1.7 APPLICATION FILM THICKNESS: The pavement marking material shall be applied at a thickness of not less than 90 mils for all roads. In no case shall it exceed a thickness of 120 mils.

442.4.2 SAMPLING AND TESTING: Samples will be taken after delivery. Any water added to the container by the manufacturer shall be considered part of the formulation and will be mixed with the paint after delivery and prior to sampling. Paint samples will be taken in accordance with the NMDOT Traffic Paint Sampling and Testing Procedures on file with the NMDOT State Materials Bureau. The City reserves the right to have an inspector present to observe the manufacturing process. Also, the City reserves the right to require manufacturers' reports of batches delivered to field locations. All tests shall be performed according to ASTM, AASHTO, Federal Test Method Standard Number 141 or methods designated by the State.

# 442.4.3 PACKAGING.

442.4.3.1 CONTAINERS: The thermoplastic material shall be delivered in cardboard containers or plastic bags of sufficient strength to permit normal handling during shipment and handling on the job without loss of material. The net weight of each container shall be approximately 50 - 55 pounds. When supplied in bags the construction of the bag shall be such that it can be placed into the melter with the thermoplastic striping material to become part of the finished product.

442.4.3.2 LABELING: Each container shall be clearly marked to indicate the color of the material, the process batch number, the manufacturer's product number, the manufacturer's name and address and the date of manufacture.

# 442.5 MEASUREMENT AND PAYMENT.

442.5.1 Hot thermoplastic reflectorized pavement striping will be measured by the linear foot along the centerline of the pavement stripe and will be based on a 4inch wide stripe. Measurements for striping with a width greater than the basic 4-inch wide stripe, as shown on the plans or directed by the ENGINEER, will be made by the following method:

(plan width of markings in inches) x (linear feet) 4 inches 442.5.2 No payment will be made for skips (spaces) in the line. No payment will be made for defective thermoplastic reflectorized pavement markings. No additional payment shall be made for repaired or replaced thermoplastic material.

442.5.3 The accepted quantities of hot thermoplastic pavement markings will be paid for at the contract unit price per linear foot which shall include the cost for furnishing all labor, materials, and equipment to satisfactorily complete the work. The cost for maintaining and protecting the markings from traffic during the marking operations shall be included in the contract unit price.

442.5.4 Hot thermoplastic pavement marking words and symbols will be paid for at the contract unit price per each which shall include the cost for furnishing all labor, materials, and equipment to satisfactorily complete the work. The cost for maintaining and protecting the markings from traffic during the marking operations shall be included in the contract unit price.

#### SECTION 443

#### PAVEMENT MARKING REMOVAL

443.1 GENERAL. This work consists of the removal of pavement stripes and other pavement markings composed of paint, thermoplastics, scotch tape, vinyl pads, calcined flint, or spray plastic by water blasting or surface planning, or as approved by the ENGINEER.

443.2 EQUIPMENT: The CONTRACTOR shall furnish all equipment required to complete the removal of existing pavement markings identified in the plans per this section.

443.3 CONSTRUCTION REQUIREMENTS.

443.3.1 MARKING REMOVAL: Existing markings may be removed by either water blasting or surface planning, or as approved by the ENGINEER.

443.3.2 ERADICATION: Existing markings identified to be removed shall be completely obliterated to a maximum depth of .25 inches and for a width equal to two times the width of the stripe or marking to be removed.

443.3.3 CONFLICTING MARKINGS: Should the pavement marking removal operation result in a scaring of the roadway surface greater than .25 inches or a condition in which the removed marking could be interpreted to be, due to the scaring of the roadway surface, a active pavement marking, the CONTRACTOR shall patch the roadway surface so that area effected by the marking removal is similar to the surrounding pavement. Areas considered to be conflicting with roadway markings shall be determined by the ENGINEER. The CONTRACTOR shall submit a plan identifying the method of patching to the ENGINEER for approval.

443.3.4 The CONTRACTOR shall submit a traffic control plan to the ENGINEER for approval prior to the commencement of work.

443.3.5 The CONTRACTOR shall remove and dispose of all debris arising from the stripe or pavement marking removal operation as directed by the ENGINEER.

443.4 MEASUREMENT AND PAYMENT.

443.4.1.1 Removal of pavement stripe will be measured by the linear foot, complete.

443.4.1.2 Removal of pavement marking composed of thermoplastics, vinyl pads, calcined flint to spray plastic will be measured by the square foot, complete.

443.4.2 Patching of pavement to eliminate conflicts between the scared pavement and permanent striping shall be considered incidental to the cost associated with marking removal. CONTRACTOR shall conduct pavement marking removal operation as to minimize the need for pavement patching.

# Section 450 TRAFFIC SIGNS AND SIGN STRUCTURES

450.1 GENERAL: This work shall consist of furnishing and installing traffic signs and sign structures in accordance with the Manual on Uniform Traffic Control Devices (MUTCD), and in compliance with the specifications and details shown on the plans at the locations shown on the plans, or as established by the ENGINEER.

450.2 REFERENCES

- 450.2.1 Aluminum Association Standards, Latest Edition.
- 450.2.2 American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications, Latest Edition.
  - M120 Zinc (ASTM B6)
- 450.2.3 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition.

A123 Zinc (Hot Galvanized) on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strips.

A525 Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

B209 Aluminum and Aluminum-Alloy Sheet & Plate

B545 Electrodeposited Coatings of Tin

E97 Directional Reflectance of Opaque Specimens by Fiber Photometry

450.2.4 Federal Highway Administration (FHWA) Standards, Latest Edition.

Standard Highway Signs and Markings

Color Specifications for Retroreflective Sign and Pavement Marking Materials

- 450.2.5 Manual on Uniform Traffic Control Devices (MUTCD), Latest Edition
- 450.2.6 This Publication, Latest Edition

Standard Detail Drawings for Signing & Striping, Section 2900

450.2.7 United States Standards, Latest Edition

#### 450.3 MATERIALS

450.3.1 GENERAL: Provide materials manufactured in accordance with the requirements of ASTM D 4956, current version.

#### 450.3.2 REFLECTORIZED SHEETING

450.3.2.1 Use retroreflective sheeting included in the *Approved Products List* or as approved by the ENGINEER. Provide certification that sheeting is in accordance with ASTM D 4956, current version. *All permanent signing shall consist of Type XI sheeting.* 

Provide sheeting that has a smooth, flat exterior film with retroreflective elements homogeneous in appearance, weather resistant, and with a protected, pre-coated adhesive backing.

All signs must be manufactured of ASTM D4956-11a Type XI Sheeting (3M DG3 4900 Series, or Engineer approved equivalent) which will be attached to the aluminum sign blank. All warning signs shall be manufactured with Fluorescent Yellow (3M DG3 4080 Series, or Engineer approved equivalent) ASTM Type XI Sheeting. Sign imaging shall be in compliance with the reflective sheeting manufacturers matched component system. Sign imaging shall consist of an acrylic based electronic cuttable film (3M 1170 Series, or Engineer approved equivalent) or silk screened with the standard highway colors. Sians containing silk screening shall have an anti-graffiti protective coating, a protective overlay film (3M 1160, or Engineer approved equivalent) shall be used that is designated to comply with the underlying reflective sheeting match component system.

#### 450.3.2.2 COLORS

450.3.2.2.1 The colors of the retroreflective sheeting are white, yellow, red, orange, green, blue, brown, fluorescent orange, fluorescent yellow, and fluorescent yellow-green. Provide the diffuse day color of the retroreflective sheeting in accordance with ASTM D 4956, current version, Table 13. Provide colors that comply with the chromaticity limits as shown in *Table 450.1 Color Specification – Chromaticity Coordinates*. Provide fluorescent colors that comply with the chromaticity limits in ASTM D 4956, current version.

450.3.2.3 COEFFICIENT OF RETROREFLECTION

Provide sign sheeting with a coefficient of retroreflection, expressed as Specific Intensity per unit area, or average candlepower per foot-candle per square foot. Ensure the intensity values meet at least the minimum values at  $0.2^{\circ}$  and  $0.5^{\circ}$  observation (divergence) angles, and, when specified in the Contract, at least the minimum values at  $0.1^{\circ}$  and/or  $1.0^{\circ}$  observation angles. Ensure intensity values are in accordance with *Table 450.2, Type XI* 

#### TRAFFIC SIGNS AND SIGN STRUCTURES

Sheeting – Minimum Coefficient of Retroreflection. Conduct testing methods in accordance with ASTM E 810.

#### 450.3.2.4 RETROFLECTIVE SHEETING BACKING

450.3.2.4.1 Provide backing for sheeting Type XI in accordance with ASTM D 4956, current version.

#### 450.3.2.5 RETROREFLECTIVE SHEETING WORK-MANSHIP AND DURABILITY

450.3.2.5.1 Use retroreflective sheeting material in accordance with ASTM D 4956, current version. Provide sheeting material sufficiently strong and flexible enough for handling, processing, and application in accordance with the manufacturer's recommendations without stretching.

450.3.2.5.2 When processed and applied in accordance with recommended procedures, sheeting material must be weather resistant and, following cleaning, must show no discoloration, cracking, blistering, or dimensional change.

When exposed to normal traffic and weather, sheeting material must not support fungus growth or accumulate dirt that reduce brightness before cleaning to less than 75% of the brightness after cleaning, measured at 0.2° divergence and -4° incidence. Use a sheeting surface that can be refurbished by cleaning and clear over coating in accordance with manufacturer's recommendations.

Apply retroreflective sheeting to a treated substrate, as recommended by the manufacturer. Ensure that layers of paint and sealer are dry before applying succeeding coats and before packaging. Ensure finished signs have a smooth and uniform surface and that letters and numbers are clean-cut and sharp. Ensure the sheeting surface is solvent resistant and can be cleaned with a soft, clean cloth dampened with VM & P naphtha or mineral spirits.

# 450.3.2.6 RETROREFLECTIVE SHEETING DELIVERY AND HANDLING

450.3.2.6.1 Retroreflective sheeting shall be delivered in good condition and shall have a good appearance, free from ragged edges, cracks, and extraneous materials. When retroreflective sheeting is furnished in continuous rolls, splices shall be smooth with no discernible line of demarcation, and the sheeting shall be suitable for continuous application. Retroreflective sheeting shall be packaged so that no damage or defacement can occur during shipment or storage. Sheeting shall be used within the time frame recommended by the manufacturer.

#### 450.3.2.7 MULTIPLE PIECES OF SIGN SHEETING

450.3.2.7.1 Sign faces comprising of two (2) or more pieces or panels of retroreflective sheeting shall match in color and provide uniform appearance and brilliance by day and night. The entire face of each sign panel shall be covered with one (1) un-spliced sheet of retroreflective sheeting, except that splicing is permissible where the substrate panel exceeds 48 inches in vertical dimension. No vertical splicing of sheeting shall be used. Materials shall be color-matched and the top piece shall overlap the bottom by a minimum of 1/2 inch in order to eliminate water penetration.

	Chromaticity Coordinates								
COLOR	1		2			3	4		
	X	У	x y		X	x y		у	
White	0.310	0.313	0.328	0.331	0.316	0.345	0.300	0.327	
Yellow	0.515	0.484	0.545	0.454	0.505 0.433		0.475	0.460	
Red	0.586	0.324	0.664	0.336	0.708	0.292	0.613	0.297	
Orange	0.558	0.352	0.636	0.364	0.570	.570 0.429 0.506		0.404	
Green	0.130	0.387	0.180	0.410	0.155	0.478	0.107	0.457	
Blue	0.138	0.065	0.112	0.135	0.160	0.170	0.176	0.120	
Brown	0.430	0.340	0.610	0.390	0.550	0.450	0.430	0.390	

Table 450.1 Color Specification – Chromaticity Coordinates

# TRAFFIC SIGNS AND SIGN STRUCTURES

OA	EA	White	Yellow	Orange	Green	Red	Blue	FI. Yellow- Green	FI. Yellow	FI. Orange
0.2	-4	570	425	213	57	114	26	455	340	200
0.2	30	215	160	80	21	43	10	170	130	75
0.5	-4	400	300	150	40	80	18	320	240	140
0.5	30	150	112	56	15	30	6.8	120	90	52

#### Table 450.2 Type XI Sheeting – Minimum Coefficient of Retroreflection

Where: OA = Observation Angle in Degrees EA = Entrance Angle in Degrees

# 450.3.2.8 SCREENING INKS AND PROCESS PASTE

450.3.2.8.1 Unless otherwise prohibited, screening inks, process pastes or film overlays can be used, in lieu of manufactured colors at the option of the sign manufacturer, to produce both the legend and background. Only the film overlays or screened colors of green, blue, red, brown and black may be used. Only those screening inks, process pastes or film overlays recommended by the retroreflective sheeting manufacturer shall be used. Said recommendations shall be obtained in writing and a copy filed in accordance with the requirements of this Section 450.

450.3.2.8.1.1 OUTDOOR WEATHERABILITY: The outdoor weatherability of the applied screening inks, process paste or film overlay shall be equal to the outdoor durability of the retroreflective sheeting.

450.3.2.8.1.2 ADHERENCE: No screening inks, process pastes or film overlay shall be removed when tested by applying cellophane tape over a properly cured, color processed area and removing the tape with one quick motion. The tape shall be 3/4 inch wide 3M Company Scotch Brand Cellophane Tape No. 600, or approved equal.

450.3.2.8.1.3 SOLVENT RESISTANCE: After proper curing, screened sign faces shall be solvent resistant to cleaning solvents recommended by the manufacturer of the retroreflective sheeting and the screening inks, process pastes, and film overlay.

450.3.2.8.1.4 VANDAL RESISTANCE: Screened sign faces shall be resistant to aromatic type solvents. The process and materials used shall be as recommended by the manufacturers of the retroreflective sheeting, screening inks, process pastes, and film overlay in order to facilitate the removal of paints or other oil based matter sprayed or painted on signs.

450.3.2.8.1.5 COLOR: Use a sign face color in accordance with ASTM D 4956, current version, and conforming to the Standard Highway Signs and Markings manual.

450.3.2.8.1.6 RETROFLECTIVE INTENSITY (Transparent Colors): Process and apply transparent colored inks or transparent colored film overlays in accordance with the sheeting manufacturer's recommendations.

Ensure that the transparent color area processed on white sheeting provides a minimum retroreflective intensity value of at least 70% of the values specified in *Table 450.2, Type XI Sheeting – Minimum Coefficient of Retroreflection,* for each color at 0.2° OA and -4° EA (or 0.1° and/or 1.0° observation angles if, specified in the Contract).

450.3.2.8.1.7 PROCESS COLORS ON SHEETING: Ensure the retroreflective intensity values are 70% of the retroreflective values specified in *Table 450.3*, *Retroreflective Intensity per Process Color* Corresponding values at 0.2° OA and -4° EA are included in Table 450.3.

450.3.2.8.1.8 PROCESS INKS: Ensure that process inks equal 70% of the coefficient of retroreflection of new sheeting and 70% at the end of the warranty period.

450.3.3 SIGN LEGENDS AND SHEETING

450.3.3.1 A sign legend shall contain such letters, numerals, symbols, arrows, borders, and other accessories that convey the sign's message.

450.3.3.2 Provide legends in accordance with the latest edition of the MUTCD. The legend may be:

450.3.3.2.1 0.005 in minimum thickness integral, semirigid, aluminum backed sheeting;

450.3.3.2.2 Self-adhering, machine cut sheeting; or

450.3.3.2.3 Reverse screened using weatherproof screen process enamel compatible with the background that provides the designated sign colors and retroreflectorization; or a reverse film overlaid with an approved film overlay.

Provide white Type XI Sheeting or better retroreflective sheeting for sign legends in accordance with Section 450.3.2 REFLECTORIZED SHEETING. Legends shall conform to the details shown on the plans and the provisions of the MUTCD. Color, reflectorization, and

#### TRAFFIC SIGNS AND SIGN STRUCTURES

configuration of legends shall be as shown on the plans and herein provided.

#### 450.3.4 SIGN BACKGROUNDS

450.3.4.1 Color and configuration of sign backgrounds shall be as shown on the plans. The sign face shall provide a plane surface free from warps, dents, burrs, mars, or other defects resulting from fabrication, shipment, storage, or installation. The entire sign face may be rejected because of any of these defects or because of dirty, marred, or defective background or legend. Completed sign faces mounted in place will be inspected at night.

#### 450.3.5 ALUMINUM PANEL SIGNS

450.3.5.1 Aluminum panel signs 24 inches wide or less be 0.080-inch minimum thickness 6061-T6 or 6062-H38 aluminum alloy. Aluminum panel signs wider than 24 inches shall be 0.125-inch minimum thickness 6061-T6 or 5052-H38 aluminum alloy. All aluminum alloys shall conform to the requirements of ASTM B 209 and shall be supplied as flat stock material. All aluminum panel signs shall have smooth edges and comers.

450.3.5.2 Cut corner radii in accordance with the Standard Highway Signs and Markings manual.

450.3.5.3 The aluminum sign blank shall be prepared for retroreflective sheeting as specified by the facing material manufacturer. Retroreflective sheeting, legend, and clear coat, shall be applied in accordance with manufacturer's recommendations, Section 450.3.2 RETROREFLECTIVE SHEETING and Section 450.3.3 SIGN LEGENDS AND SHEETING. сору of the manufacturer's А recommendations shall be kept on file as specified in this Section 450 for review by the ENGINEER during the periodic inspections of the manufacture's sign shop. The aluminum sign panel shall have a square punched hole to receive a carriage bolt or a lock washer for use with a carriage bolt and tamper proof nut. Hardware form mounting aluminum panel signs shall comply with the requirements of Section 450.3.6 SIGN STRUCTURES AND HARDWARE.

#### 450.3.6 SIGN STRUCTURES AND HARDWARE

450.3.6.1 Steel posts and base posts for aluminum panel signs shall be of the dimensions and cross section shown on the plans. Steel posts and base posts shall either be finished by one of the following methods:

450.3.6.1.1 Hot dipped galvanized in accordance with the requirements of ASTM A653 or ASTM A 123;

450.3.6.1.2 Hot dip galvanized zinc coating in accordance with the requirements of AASHTO M 120, followed by a chromate conversation coating and a cross-linked polyurethane acrylic exterior coating;

450.3.6.1.3 Painted with Color No. 14109 green paint. Provide paint in accordance with Federal Standard 595a, a minimum of one (1) mil in thickness.

450.3.6.2 Hardware for post assembly shall be hot dipped galvanized or cadmium plated in accordance with ASTM B766-86, stainless steel, or mechanically galvanized in accordance with ASTM B 545 (Class Fe/Sn 20). Post assembly hardware shall be of the dimensions shown on the plans.

#### 450.3.7 BOLTS

450.3.7.1 Size 5/16 inch-18 UNC for sign attachment shall be a tamper proof carriage bolt, either hot dipped galvanized, cadmium plated in accordance with ASTM B766-86, stainless steel, or mechanically galvanized in accordance with ASTM B 545 (Class Fe/Sn 20). Tamper resistant nuts, size 5/16 inch-18 UNC shall be used and fabricated from C1008 hot rolled steel, case hardened to R55-60, and plated with zinc yellow dichromate, 0.002 inch and 0.005 inch thick.

#### 450.4 CONSTRUCTION REQUIREMENTS

450.4.1 CERTIFICATION OF MANUFACTURER: The CONTRACTOR shall submit, in writing, the name of the proposed sign manufacturer, project number, and certification that all sign materials comply with the specifications.

#### 450.4.2 SIGN IDENTIFICATION

450.4.2.1 The following identification labels shall be affixed to all signs and shall include the information as listed:

450.4.2.1.1 MANUFACTURING IDENTIFICATION LABELS: These labels shall include the wording; "Manufactured By", the initials of the sign fabricator, the month and year of fabrication, the initials of the reflective sheeting manufacturer, reflective sheeting type, and the wording "Theft is a Crime";

450.4.2.1.2 CONTRACTORS IDENTIFICATION LABEL: This label shall include the CONTRACTOR's name, and date installed including month and year.

450.4.2.2 The above labels may be either die stamped in 3/8 inch letters or numerals, or made with high-tack adhesive sign sheeting (reflective or non-reflective) prepared with screened ink in  $\frac{1}{2}$  inch letters and numerals.

450.4.2.3 The labels shall be placed on the lower back side of the sign, and located so as not to fall behind any post or frame member. Dye stamping shall be performed in a manner that will not damage the finished sign. The label shall have similar weather resistance characteristics as the sheeting and shall last for at least the expected service life of the sign. The labels shall be affixed at the time the sign is manufactured.

#### TRAFFIC SIGNS AND SIGN STRUCTURES

#### 450.4.3 APPROVAL OF SHOP DRAWINGS

450.4.3.1 Standard signs shall be constructed in accordance with the detail drawing furnished to the CONTRACTOR by the City of Albuquerque. The CONTRACTOR shall submit detailed shop drawings of all special code signs (those other than the standard MUTCD coded signs) to the ENGINEER and the Traffic Engineer for approval. The CONTRACTOR shall not begin fabrication of special coded signs until the shop drawings are approved by the ENGINEER and the Traffic Engineer. These drawings shall show the complete legend, arrangement of letters and numerals, letter and numeral height, letter series, symbols, borders, and dimensions.

450.4.3.2 The CONTRACTOR shall not install the signs until the shop drawings are approved.

450.4.3.3 The CONTRACTOR must verify the post lengths with the ENGINEER and the Traffic Engineer before installation operations begin. 450.4.4 INSPECTION

450.4.4.1 All material and furnished signs shall be subject to inspection and release or installation by the ENGINEER and the Traffic Engineer at the project site prior to installation, and shall be subject to final inspection at the project site after installation. The entire sign may be rejected if there are mars, damages, stains, discolorations, or defacements resulting from fabrication, storage, shipments or installation.

450.4.4.2 The ENGINEER and the Traffic Engineer shall at all times during work hours, have free entry to the parts of the sign manufacturing plant that are involved in the manufacture and production of the signs. Adequate facilities required for inspection shall be furnished without charge to the ENGINEER and the Traffic Engineer for inspection of signs and to verify that manufactures Quality Control Program.

450.4.4.3 Test panels, twelve (12) inches by twelve (12) inches representative of each state production, shall be furnished on request to the ENGINEER and the Traffic Engineer. These panels shall be processed along with regular production runs and witnessed by the ENGINEER and the Traffic Engineer. Should there be any question as to validity of a test panel; a completed sign shall be furnished upon request. Signs not conforming in all aspects to the requirements of these specifications may be rejected and the manufacturer's QC Program may be withdrawn. The ENGINEER may select a sign at random for submittal to the City of Albuquergue's Traffic Engineering Operations Division for further inspections. The ENGINEER will return the sign to the CONTRACTOR in time for the sign to be installed in accordance with the CONTRACTOR's schedule.

450.4.5 PACKAGING AND SHIPPING: All signs shall be suitably packaged and protected for proper shipment and

storage. Signs shall be delivered undamaged to the project site.

#### 450.4.6 FABRICATION

450.4.6.1 Material ½ inch thick or less may be sheared, blanked, sawed, or milled. Material over ½ inch think shall be sawed or milled. Cut edges shall be true and smooth and free from excessive burrs or ragged breaks. Reentrant cuts shall be filleted by drilling prior to cutting. Flame cutting is not permitted.

450.4.6.2 Bolt holes shall be drilled to finish sizes.

450.4.6.3 Steel surfaces to be in contact with aluminum shall be galvanized or of stainless steel.

450.4.6.4 Aluminum surfaces to be in contact with concrete or earth shall be given a heavy coat of alkali-resistant bituminous paint.

450.4.7 INSTALLATION AND REMOVAL OF SIGNS: The CONTRACTOR shall install traffic sign structures at locations shown on the plans. Existing traffic control signs removed by the CONTRACTOR shall be delivered to locations designated by the ENGINEER. The CONTRACTOR shall verify the sign locations with the ENGINEER prior to their installations.

450.4.8 USE OF CERTIFIED SIGNS ONLY: the CONTRACTOR's sign manufacturer must supply signs with identification on the back of the sign as specified in this Section 450 which matches the approved sign manufacturer identified on the documentation letter. The CONTRACTOR shall not install permanent signs until the ENGINEER has verified that the shipment of signs delivered has a manufacturer's check list and has given the CONTRACTOR authorization to begin sign installation. The CONTRACTOR must use the manufacturer for which certification was requested and approved.

450.4.9 SIGN STORAGE: The CONTRACTOR shall store material, including posts, under a roof or otherwise covered for protection against elements. Materials shall be stored so as not to be on the ground or come in contact with surface runoff water.

450.4.10 REMOVING AND RESETTING ALUMINUM PANEL SIGNS: The CONTRACTOR shall remove existing designated plywood or aluminum panel signs, sign posts, and base posts and stockpile sign posts and base posts at locations designated by the ENGINEER, or as shown on the plans. Removed aluminum panel signs shall be reset on new steel sign posts and base posts in compliance with this Section 450 and details shown on the plans.

450.4.11 SCHEDULE: A written schedule for the removal and resetting of existing traffic signs shall be submitted to the ENGINEER for approval prior to commencement of sign removal.

# TRAFFIC SIGNS AND SIGN STRUCTURES

#### 450.5 MEASUREMENT AND PAYMENT

450.5.1 Steel posts and base or anchor posts for aluminum panel signs shall be measured per linear foot of post, complete in place.

450.5.2 Aluminum panel signs shall be measured by the square foot of sign face area mounted on drive-down posts, light pole or signal mastarm as directed by the ENGINEER, complete in place.

450.5.3 Removing and resetting of aluminum panel signs and sign structures shall be measured per each unit, complete in place.

450.5.4 Removing and disposing of aluminum panel signs and sign structures shall be measured per each unit, complete.

450.5.5 The accepted quantities of traffic signs and sign structures shall be paid for at the contract price per unit of measurement for each of the pay items listed as shown on the bid proposal.