

Standard Specifications for Road and Bridge Construction

Volume 2 of 2

Prepared by

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Working titles having a masculine gender, such as workman, workmen, and foreman, and pronouns such as he, his, and him are utilized in these Specifications for the sake of brevity and are intended to refer to persons of either sex.

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772.04 METHOD OF MEASUREMENT

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SECTION 770 HIGHWAY LIGHTING

770.01 DESCRIPTION.

This work consists of furnishing and installing highway and street lighting.

770.02 MATERIALS.

- A. **General Conditions.** All work and material shall meet the requirements of the National Electric Code, the North Dakota State Electrical Board, the local utility company, and the ordinances established by the local municipality.

All material furnished shall be new and shall meet Section 895.

- B. **Shop Drawings.** Required shop drawings shall be furnished to the Engineer for approval within 50 days after the date of Contract execution by the Department. The dimensions, type of material, and the functional characteristics of the equipment to be installed shall be provided with the shop drawings.

The Contractor shall be responsible for the accuracy of the shop drawings. The Engineer's review and approval does not relieve the Contractor of full responsibility for providing a quality product that meets specifications. The approved shop drawings shall be used for materials acceptance in lieu of certification.

The Contractor shall submit 8 sets of shop drawings on the following listed items for approval:

1. Conductors
2. Pull Box
3. Feed Point Equipment including:
 - a. Circuit breakers (enclosed in a load center-type panel board)
 - b. Enclosed relay (normally open)
 - c. Cabinet
 - d. Photoelectric cell
4. Light Standard including:
 - a. Luminaire

- b. Fuseholder
 - c. All necessary calculations and drawings used in the design of these poles.
- 5. Sign Lighting Fixture including:
 - a. Loadcenter
 - b. Luminaire
 - c. Ballast
- 6. High Mast Lighting Assembly including:
 - a. Pole
 - b. Lowering Device
 - c. Head Frame Assembly
 - d. Luminaire Ring Assembly
 - e. Winch and Hoisting Assembly including all cables
 - f. Portable Power Unit
 - g. Luminaires
 - h. All necessary calculations and drawings used in designing high mast poles.
- 7. Wall Mounted Luminaires
- C. **Certificates.** The certifications specified in Section 801.02 shall be furnished for “conduit.”
- D. **Warranties and Guarantees.** All manufacturer warranties and guarantees with respect to materials, parts, workmanship, or performance which the products bear shall be secured and included with the shop drawing submittal.
- E. **Manuals.** The Engineer shall be furnished 4 operating and maintenance manuals for the high mast equipment. These manuals shall be properly indexed and cross referenced with tables of contents. They shall contain operating procedures, recommended maintenance schedules, manufacturer and catalog numbers of electrical components, equipment parts numbers, copies of all approved shop drawings, spare parts lists, lubrication charts, etc. Each manual shall be contained in a loose-leaf, hard-covered binder.

The manuals will be distributed to the Feed Point Cabinet, City, and Planning and Design Divisions of the Department.
- F. **Additional Equipment.** The Department and the local municipality may order additional lighting equipment along with the Contractor’s shipment for the Proj-

ect. Additional equipment shall be billed to the Department or the local municipality at the Contractor's cost. The Department or local municipality will unload and store the extra equipment ordered. The Department and the local municipality shall be notified by letter informing them of the impending equipment order. The Department or local municipality will indicate the quantity of equipment desired in the Proposal. Additional equipment ordered will be limited to 10% of the total amount of the item, or items, to be supplied under the Contract.

- G. **Concrete Foundation.** Concrete used in the work shall be Class AE Portland Cement Concrete mixed and proportioned as specified in Section 802. Grout shall meet Section 806.01.

770.03 CONSTRUCTION REQUIREMENTS.

- A. **General.** Various phases of the work such as foundations, conduit, conductor, standards, and feed points shall be completed as materials become available. Individual feed point lighting circuits shall be put into service as materials become available, and the system shall not be kept inoperative for the lack of a few parts.

- B. **Cable Trench.** The trench for conductors shall be excavated as specified.

Cinders, broken concrete, and other hard or objectionable materials which might damage the conductors shall not be used for backfilling. The trench bottom shall be free of such materials before the conductor is placed.

All trenches shall be backfilled immediately after installation of conductor. Backfill material shall be tamped and compacted to the density of the adjacent material.

Street lighting multiple underground cable may be installed by the plowing method rather than in cable trench.

- C. **Concrete Foundation.** Exact location and elevation will be established by the Engineer.

Foundations shall be formed at least 6 inches into the ground. The foundation edges on top and for a distance of 6 inches into the ground shall be chamfered.

Concrete foundations of each type shall be cast in place. The foundations shall contain the necessary ground rods, rebars, anchor bolts, and conduits.

The concrete foundation for light standards and high mast poles shall be constructed to the proper elevation. There shall be no grouting between the foundation and the pole base.

The distance from the top of the anchor bolts to the foundation shall be as recommended by the light standard manufacturer or high mast pole manufacturer. The size of the anchor bolts in each foundation shall be as recommended by the light standard manufacturer or high mast pole manufacturer. Anchor bolts shall be installed and tightened as specified in Section 754.03 E.5.

- D. **Rigid Conduit.**

1. **General.** All conduit shall meet the size shown on the Plans. The inner edge of joints and the extreme ends of conduit shall be smoothed and rounded to

avoid any damage to the cable. Slip joints or running threads shall not be used for conduit couplings. When a standard coupling cannot be used, an approved threaded union shall be used. Coupling components shall be rotated until ends of conduit are brought together.

Voids from an abandoned boring hole through a roadbed shall be grouted at the Contractor's expense.

Conduit shall be installed a minimum of 24 inches below the surface. Backfill over the conduit shall be thoroughly compacted. Conduit types shall not be intermingled within a run except at feed points.

Conduit shall be laid on a slope to drain. A "tee" shall be provided where conditions permit in the highway lighting conduit line. A drainage pit shall be installed beneath each "tee". The drainage pit consists of a one-foot diameter hole 3 feet deep; filled with aggregate ranging in size from 3/4 inch to one inch; and free from clay, silt, loam, and any organic material.

The existing roadway surfacing shall remain in place and rigid conduit shall be bored or jacked under the roadway. Non-metallic conduit shall not be jacked.

Conduit runs terminating in concrete foundations shall be brought at least 2 inches above the finished grade of the foundation. Conduit runs terminating in concrete pull boxes shall be brought 2 inches beyond the inside wall of the box and be a minimum of 2 inches above the bottom. Conduit shall enter concrete foundations or pull boxes from the direction of the conduit or cable run. Conduit placed in concrete foundations for lighting circuit shall have a minimum nominal diameter of 2 inches unless continuous conduit runs are installed, of the size specified for the run.

Rigid conduit bends, except factory bends, shall have an inside radius of at least 6 times the nominal diameter of the conduit. Where field bends are made, the bending shall be accomplished without crimping or flattening the conduit. The longest practicable radius shall be used.

Whenever light standard foundations are installed and there is not a continuous run of conduit, the conduit installed in the concrete foundation shall be 2-inch diameter with rigid conduit elbows. The cost shall be included in the price bid for "Concrete Foundation."

2. **Metallic Rigid Conduit.** The terminal ends of all metallic conduit shall be fitted with grounding bushings. Metallic conduit end threads shall be painted with pipe joint compound and threaded into couplings to butt together when making up joints. Where the conduit is installed before the wiring, all open ends of metallic conduit shall be threaded and capped with standard pipe caps. Approved conduit bushings shall be installed to avoid damage to the cable when the caps are removed. Caps, bushings, exposed threads, and scuffed areas shall be painted with rust-preventative paint.
3. **Nonmetallic Rigid Conduits.** Plastic conduit ends shall be painted with a solvent weld, as recommended by the conduit manufacturer, before insertion in a coupling.

E. Conductors.**1. General.**

- a. Conductors and cables shall be of the size and type shown on the Plans.
- b. Electrical installation shall be made by and supervised by licensed electricians.
- c. All cable run through conduit shall be pulled by hand and shall not be strained.
- d. Splicing of conductors will be permitted only in light standard bases and feed points. Splices shall be of the compression type. Underground splices shall not be permitted.
- e. Cables shall terminate only at the meter box, light standards, or other equipment. They shall be connected with sufficient slack to prevent any strain on the cable or connections.
- f. All electrical connections shall be made without solder.
- g. All bases, standards, control cabinets, and exposed metal parts shall be grounded. Bolted pressure connectors to all ground rods shall be provided.
- h. Cable shall be protected from moisture when it is installed before the standards are installed.
- i. All cable shall be identified as to its function.
- j. All necessary wiring connections shall be made. These connections shall be included in the price bid for conductors.

2. Highway Lighting Circuits.

- a. Each lighting circuit shall be installed in a separate trench.
- b. Where one lighting circuit crosses another, a 4-inch bed of sand shall be placed between the circuits at the point of crossing. Circuits installed by plowing do not require a sand bed.
- c. The continuous grounding conductor (not a neutral) shall be looped through each foundation and feed point and bonded to the light standard and feed point cabinet.
- d. Sufficient length of internal light standard conductor shall be provided so the fuse kit can be withdrawn from the standard through the hand hole.

3. Additional Cable Quantities. Additional cable quantities shall be installed to provide for slack and the wiring of feed points and light standards as follows:

- a. Ten feet at the feed point.

- b. Four feet at each foundation for each incoming and outgoing circuit.
- c. Three feet of slack for each single conductor installed in cable trench at each light standard foundation for each incoming and outgoing circuit. This extra conductor shall be installed in a series of "S" curves in the trench. This shall not apply to multiple conductor cable.
- d. Six feet at pull boxes where connections are made.

- F. **Pull Box.** The top surface of the pull box shall be flush with surfaced areas and approximately one inch above earth or sodded areas. The down side of pull boxes installed on inslopes shall not extend more than 4 inches above the ground.
- G. **Feed Point.** The complete feed point shall be furnished including the cabinet, padlock, conduit, conductor, service entrance heads, meter sockets (if required), and ground rods.

All equipment mounted in a feed point cabinet shall be arranged, installed and wired as required.

The cabinet shall contain a photo electric cell near the top of the cabinet, and when the cabinet is installed, the cell shall face north.

The local utility company shall be contacted for specific locations of feed points. The local utility company will furnish and install the required single phase voltage service connection and any required meter. The Contractor shall lock and seal any switch box as required by the utility company or local governmental agency.

The Contractor shall provide and bear all costs for the electrical service necessary to operate and maintain the lighting system until the project is accepted by the Engineer.

- H. **Light Standards.** Light standards and mast arms shall conform in style, type, and dimensions to the Contract requirements. Convenience or festoon circuits shall be provided when required.

The light standard shall be plumbed with shims or leveling nuts. The mast arms shall be perpendicular to the roadway centerline.

The assembled standard shall, under dead load and at equal ambient temperatures, be as near to true vertical alignment as practical.

The anchor bolts shall be tightened securely. A minimum of 2 threads shall be exposed above the nuts. Bolts in a multi-directional slip base shall be torqued to meet the requirements specified.

- I. **Street and Sign Lighting Luminaires.** The luminaire operating voltage, lamp type, and lamp wattage shall be as specified. The street luminaire shall have the IES distribution as specified.

The ballast shall be installed as specified.

A plug of oakum shall be inserted in the luminaire wire entrance to prevent moisture and insects from entering the luminaire.

Each street light luminaire shall be fused in the light standard base. The fusing shall meet Section 895.08.

- J. **High Mast Lighting Assembly Installation.** Installation and assembly drawings shall be provided by the manufacturer showing the assembly sequence, lift point, and erection procedure with suggested equipment for installation. A check list of all parts identifiable by structure type and number shall be supplied.

The structure shall be shop blast cleaned according to the Steel Structures Painting Council Surface Preparation Specification "No. 6 Commercial Blast Cleaning," SSPC-SP6. The outer surface shall not be marred by careless handling and shall be in a condition conducive to uniform weathering. The factory-cleaned surface shall be protected from being contaminated by oil, grease, paint, crayon, chalk, or other markings during transportation, storage, and erection.

Dirt, mortar leaks, spatters, and other foreign substances shall be removed by washing with clean water or other approved methods. A nonuniform appearance of these surfaces due to recleaning may require field blast cleaning after erection.

A representative of the manufacturer shall assist in the assembly and erection of the pole, lowering device, and luminaires. The luminaires shall be aligned, as required, to light the areas intended.

- K. **Sodium Vapor Wall-Mounted Luminaire.** The wall-mounted luminaire shall be mounted in the location shown.

The mounting bolts shall be installed using a threaded insert. The wall-mounted luminaire shall be attached by a minimum of 3 bolts of 1/4 inch diameter.

Each luminaire shall be fused in the junction box provided. The fusing shall meet Section 895.08.

- L. **Sodium Vapor Underpass Ceiling-Mounted Luminaire.** The ceiling-mounted luminaire shall be mounted in the location shown.

The mounting bolts shall be installed using a threaded insert. The ceiling-mounted luminaire shall be attached by 4 bolts of 1/4 inch diameter.

Each luminaire shall be fused in the junction box provided. The fusing shall meet Section 895.08.

- M. **Sign Lighting.** All equipment including luminaire, ballast, load centers, and conduit shall be arranged, installed, and wired in a manner approved by the Engineer. Mounting on the sign structure shall be as shown on the Plans.

Conduit of the size shown on the Plans shall be installed from below ground line to the load centers. Ground rods and conductor shall be installed for new sign lighting systems.

- N. **Revise Concrete Foundation.** Concrete shall be removed from an existing concrete foundation, conduit shall be installed, and the concrete shall be replaced with a commercial non-shrink mortar.

O. Remove Existing Equipment.

1. **General.** Before removing existing equipment, arrangements shall be made with the local utility to disconnect the power source.

The Contractor shall disconnect all wiring to the equipment and completely remove the item from its foundation. Equipment shall be removed without damage and transported to the designated storage site. Any items damaged in removal, transportation, or storing shall be replaced at the Contractor's expense.

The existing foundations shall be removed to a depth of 2 feet below the ground line and the surface restored to match adjacent areas. Foundation removal shall be considered incidental to removal of equipment.

All equipment removed shall remain the property of the Department.

2. **Removal of Light Standards.** The Contractor shall disconnect the luminaire receptacle wires at the fuses and remove the luminaire from the mast arm before the equipment is stored.
3. **Remove Feed Point.** The switch box, meter trim, and conduit shall be removed for salvage. The local utility will remove the meter.

- P. **Relocate Light Standard.** Light standards shall be removed from its present location and installed at a new location as specified.

The wires to the luminaire shall be disconnected at the fuses and the light standard removed as specified in Section 770.03 O. The light standard shall be installed in the new location as specified in Section 770.03 H.

Relocated light standards shall be painted with one coat of aluminum paint meeting Section 852.01 A. and application shall be as specified in Section 770.03 Q.2.

Q. Painting.

1. **Materials.** Feed point cabinets shall be painted with 2 coats of exterior enamel meeting Section 852.01 D. The color shall be specified on the Plans.

The base and lower 12 feet of light standards with attached pedestrian signal heads shall be painted with 2 coats of enamel of the color specified. The paint shall meet the requirements of the latest revision of Federal Specification TT-E-489.

2. **Application.** Paint shall be applied only when the air temperature is at or above 45°F. and below 100°F. It shall not be applied when the air is misty, dusty, or otherwise unsatisfactory for work. Material painted under cover in damp or cold weather shall remain under cover until dry or until weather conditions permit its exposure.

All surfaces that require preparation shall be sandblasted. Existing paint remaining along the edges of blast cleaned areas shall be feathered and cleaned to assure a bond of new to old paint.

Paint shall be applied during daylight hours by brushing or spraying. After application, the paint film shall be smooth and uniform without skips or areas of excessive paint. If spraying results in unsatisfactory surfaces, brushing will be required. The previously applied coat of paint shall have dried before the next coat is applied.

Only airless spray painting equipment shall be used. Paint shall be continually agitated during the spraying operation. The paint shall be applied in a fine spray so a uniform thickness is obtained when dry. If required, the paint shall be immediately brushed out to secure uniform coverage and eliminate runs, wrinkling, blistering, and air holes. If adequate coverage cannot be obtained at rivets, bolt head, nuts, corners, and edges, hand brushing will be required before spraying.

Protective shields shall be provided to protect adjacent property from drift. Spray painting shall be suspended whenever application or drift is not being properly controlled.

The Contractor shall protect all adjacent property against spatters of paint or paint materials. The Contractor shall prevent dust and dirt from coming in contact with the freshly painted surfaces.

Painted areas that become scratched or marred shall be touched up with matching paint after erection, except that galvanized equipment shall be touched up with material meeting Section 854.

- R. **Repairs to Sidewalks and Roadways.** Portions of sidewalks or roadways removed for installation of conduit, cable trench, or foundations shall be refilled to the original thickness using materials equal to the material removed. When repairing sidewalks one-inch expansion board shall be installed between the existing curb and sidewalk.

Where the concrete for sidewalk repair or replacement is adjacent to concrete foundations, the concrete foundations shall be wrapped with one-inch expansion board.

Pavement openings shall be kept to a minimum, and not more than one lane of the pavement shall be closed to traffic at any time.

Provisions shall be made to cover all openings so the entire street may be opened to traffic after working hours and on holidays.

Customer access to all businesses shall be maintained.

S. **Tests and Acceptance.**

1. **Tests.** When the installation is complete and at the time designated by the Engineer, the operating test shall be conducted for approval. The Contractor shall furnish instruments and personnel required for all tests, record all test results, and shall be present during all tests and inspections. Nighttime tests and inspections may be held when directed by the Engineer.
2. **Acceptance.** Upon completion of the lighting system operating tests, the lighting system shall be put into service and any equipment that is omitted, is

improperly installed, or malfunctions during a 90-day period shall be replaced or corrected at the Contractor's expense. The lighting inspection shall be held during this period.

T. Welding applications as specified in Section 105.06 D.

770.04 METHOD OF MEASUREMENT.

A. **General.** Each item will be measured complete, in place. Some of the following pay items list specific auxiliary equipment as part of the pay item and will not be measured separately. These pay items shall not be limited to only the listed auxiliary equipment. Other equipment required for the pay item to function will not be measured separately.

Opening and repairing sidewalks and roadways shall not be measured for payment, but shall be included in the price bid for the item which necessitated the opening and repairing.

B. **Cable Trench.** Each type will be measured by the Linear Foot. Measurement will be made along the slope of the ground at the centerline of the trench. Measurement will not include the installation of conduit.

C. **Concrete Foundation.** Each type will be measured by the number installed. The anchor bolts, reinforcing rods, conduit bends, ground rods, and tightening as specified herein shall be included in the price bid for this item.

D. **Conduit.** Each specified size will be measured by the Linear Foot. Conduit that is placed in concrete foundation, at feed points, and on overhead and bridge sign structures will not be measured for payment under this item. The method used to install conduit such as boring, jacking, and trenching will not be measured, but will be included in the price bid for Conduit.

E. **Multiple Underground Cable.** Each specified size will be measured separately by the Linear Foot based on the actual measured length of the cable trench, conduit in which the cable is installed, and the additional cable required by Section 770.03 E.3.

F. **Underground Conductor.** Each specified size and type will be measured separately by the Linear Foot based on the actual measured length of cable trench, conduit in which the conductor is installed, and the additional conductor required by Section 770.03 E.3.

G. **Feed Point.** Each type will be measured by the number installed. Conduit, cabinets, padlocks, conductor, service entrance heads, meter trim, and ground rods shall be incidental to this item.

H. **Light Standard.** Each specified type and size will be measured by the number installed and will include the light standard, base, mast arm, fused disconnects, internal wiring, and required shims or leveling nuts. Festoon outlets shall be included when they are specified.

I. **High Mast Lighting Assembly.** Each type will be measured separately by the number installed and accepted. The structure, lowering device, ballast, luminaire and mounting will be incidental to this item.

- J. **Light Standard Extension.** Each specified type and size will be measured by the number installed and will include the extension, mast arm, fused disconnects, internal wiring, and connecting hardware.
- K. **Street Lighting Luminaire.** Each specified type and wattage will be measured by the number installed. This item will include the electrical connection.
- L. **Bridge Sign Lighting and Overhead Sign Lighting.** Each of these items will be measured as a complete unit. Luminaires, ballast, conduit, conductor, load center mounting attachment, and all other necessary equipment to complete the installation will be incidental to these items.
- M. **Sodium Vapor Wall-Mounted Luminaire.** This item will be measured by the number installed. The junction box, fusing, conductor, conduit from the junction box to the luminaire mounting attachment, and all other necessary equipment to complete the installation will be incidental to this bid item.
- N. **Sodium Vapor Underpass Ceiling-Mounted Luminaire.** This item will be measured by the number installed. The junction box, fusing, conductor, conduit from the junction box to the luminaire mounting attachment, and all other necessary equipment to complete the installation will be incidental to this bid item.
- O. **Relocate Light Standard.** This item will be measured by the number of light standards relocated. The removal from the existing location, transporting to the new location, painting, and removal of the existing foundation will be incidental to this bid item.
- P. **Remove Light Standard.** This item will be measured by the number of light standards removed. Removing the foundation, transporting, and storing the light standard will be incidental to this bid item.
- Q. **Remove Feed Point.** This item will be measured by the number of feed points removed. Disconnecting, transporting, and storing the feed point will be incidental to this bid item.
- R. **Revise Concrete Foundation.** This item will be measured by the number of foundations revised. Removal and replacement of concrete and installation of conduit shall be incidental to this bid item.

770.05 BASIS OF PAYMENT.

Quantities measured as provided above will be paid for at the contract prices for the pay items listed on the Plans and in the Proposal Form. This payment shall be full compensation for all labor, equipment, and materials necessary to complete the work.

Payment will be made at Contract Unit Prices for the following:

| Pay Item | Pay Unit |
|--|-----------------|
| Cable Trench | Linear Foot |
| Concrete Foundation | Each |
| Conduit ____ Size | Linear Foot |
| Multiple Underground Cable ____ Size | Linear Foot |
| Underground Conductor ____ Size | Linear Foot |
| Feed Point | Each |
| Light Standard | Each |
| High Mast Lighting Assembly | Each |
| Light Standard Extension | Each |
| Street Lighting Luminaire | Each |
| Bridge Sign Lighting | Each |
| Overhead Sign Lighting | Each |
| Sodium Vapor Wall-Mounted Luminaire | Each |
| Sodium Vapor Underpass Ceiling-Mounted Luminaire | Each |
| Relocate Light Standard | Each |
| Remove Light Standard | Each |
| Remove Feed Point | Each |
| Revise Concrete Foundation | Each |

SECTION 772 HIGHWAY TRAFFIC SIGNALS

772.01 DESCRIPTION.

This work consists of furnishing and installing flashing beacons and traffic signals.

772.02 MATERIALS.

- A. **General.** All work and material shall meet the National Electric Code, the North Dakota State Electrical Board, the local utility company, and the ordinances established by the local municipality.

The word and phrase definitions shall be as defined in Section 1 "Definitions" of the National Electrical Manufacturer's Association (NEMA) Standard Publication No. TS 2 Traffic Control Assemblies with NTCIP Requirements.

All materials shall be new and shall meet Section 896.

- B. **Shop Drawings.** Required shop drawings shall be furnished to the Engineer for approval within 50 days after the date of Contract execution by the Department. The dimensions, type of material, and the functional characteristics of the equipment to be installed shall be provided with the shop drawings.

The Contractor shall be responsible for the accuracy of the shop drawings. The Engineer's review and approval does not relieve the Contractor of full responsibility for providing a quality product that meets specifications. The approved shop drawings will be used for materials acceptance in lieu of certification. The Contractor shall submit 8 sets of shop drawings on the following listed items for approval:

1. Conductors
2. Pull Box
3. Saw Slot Sealant
4. Feed Point Equipment including:
 - a. Safety switch and lightning protection device
 - b. Flasher
 - c. Time Clock
 - d. Cabinet
5. Traffic Signal Standards including all necessary calculations and drawings used in designing these poles.
6. Combination Standards including all necessary calculations and drawings used in designing these poles.
7. Traffic Signal Heads
8. Beacon Heads
9. Pedestrian Signal Heads
10. Pedestrian Push Button
11. Detector Cabinet
12. Traffic Signal Controller with all components including, when required:
 - a. Controller
 - b. Flashers
 - c. Conflict Monitor
 - d. Coordination Equipment
 - e. External Logic Unit
 - f. Solid State Load Switches
 - g. Detector Amplifier

- h. Lightning Protection Device
- i. Cabinet

13. Emergency Vehicle Pre-Emption Equipment

- C. **Certification.** The certifications specified in Section 801.02 shall be furnished for conduit.

The Contractor shall provide a certification that all components of the LED signal modules meet the Institute of Transportation Engineers Standards.

- D. **Warranties and Guarantees.** All manufacturer warranties and guarantees with respect to materials, parts, workmanship, or performance which the products covered by the proposal bear shall be secured and included with the shop drawing submittal.

- E. **Wiring Diagrams.** The Engineer shall be furnished 4 complete sets of traffic signal cabinet wiring diagrams showing in detail all circuits and parts at the time the cabinet and control equipment is delivered.

These wiring diagrams will be distributed to the traffic signal cabinet, City, and Planning and Design Divisions of the Department.

Wiring diagrams shall contain all the control equipment and their associated connecting cables and termination points. Each wire in each connecting cable on the wiring diagram shall be identified as to its function and terminal number. Each terminal on the wiring diagram shall list the cable designation and connector letter or number of the wire terminated at that point. In addition, the wiring diagram shall contain a diagram showing the location of all control equipment, terminals, etc., within the cabinet as well as intersection layout showing the location of vehicle signal faces, pedestrian signal indications, loop detectors, pedestrian push buttons, etc., all labeled as shown on the Plans.

The main cabinet wiring diagram shall also contain the logic (schematic) diagram of the following as required:

1. In and Out Flash Circuitry
2. Detector Paralleling Circuitry
3. Detector Time Delay Circuitry
4. Calling Detector Circuitry
5. Coordination Interface Circuitry
6. Not Adding Initial During Non-Automatic Circuitry
7. Actuated Permissive Yield Period Circuitry
8. All other logic diagrams contained in the external logic assembly unit
9. Emergency Vehicle Pre-Emption Circuitry and Interface Points

- F. **Service Manuals.** The Engineer shall be furnished 4 service and operating manuals for the traffic signal controller unit, emergency vehicle pre-emption controller, and the Engineer will distribute the manuals as stated in Section 772.02 E.

Each service manual shall include the following minimum information:

1. Detailed description of operation and instructions for initial set-up
 2. All schematics and wiring diagrams of the unit
 3. Recommended servicing and service hints
 4. Complete parts list
 5. Recommended spare parts list
- G. **Additional Equipment.** The Department and the local municipality may order additional signal equipment along with the Contractor's shipment for the Project. Equipment shall be billed to the Department or the local municipality at the Contractor's cost. The Department or local municipality will unload and store any extra equipment ordered. The Department and the local municipality shall be notified by letter informing them of the impending equipment order. The Department or the local municipality will indicate the quantity of equipment desired in the Proposal. The quantity of equipment to be ordered by the Department or municipality will be limited to 10% of the total amount of the item, or items, to be supplied under the Contract.
- H. **Concrete Foundation.** Concrete used in the work item shall be Class AE Portland Cement Concrete mixed and proportioned as specified in Section 802. Grout shall meet Section 806.01.

772.03 CONSTRUCTION REQUIREMENTS.

- A. **General.** Various phases of the work such as foundations, conduit, conductor, standards, feed points, and controllers shall be completed as the materials become available. Signal installations at individual intersections shall be put into service as materials become available, and the system shall not be kept inoperative for the lack of a few parts.
- B. **Concrete Foundations.** Concrete Foundations shall meet Section 770.03 C.
- C. **Rigid Conduit.** Rigid Conduit shall meet Section 770.03 D.
- D. **Conductors.**
1. **General.** General requirements shall meet Section 770.03 E.1.
 2. **Traffic Signal Control Circuits.**
 - a. The traffic signal control circuits shall be in the location and have the number of conductors as shown in the Contract.
 - b. No. 16 AWG, 2-conductor cable shall be installed from each pedestrian push button to the controller. The cable shall be unspliced.

- c. Control cables running from the terminal block in each traffic signal standard base to each traffic signal head shall be installed. No. 12 AWG, 3-conductor cable shall be installed for each 2-section pedestrian head and No. 12 AWG, 5-and 7-conductor cable shall be installed for each 3-and 5-section vehicular head.
- d. Terminal blocks shall be provided for connections of control circuits in signal standard bases.
- e. Traffic signal control circuits shall not be spliced.

3. Loop and Loop Lead-in Conductor.

- a. The loop conductor shall not be spliced.
- b. The lead-in conductor shall not be spliced except at the pull box where this conductor and the loop conductor are spliced.
- c. The installation and splicing methods shall be as recommended under installation of loop detectors, Section 772.03 F.
- d. Microloop Probe set shall consist of furnishing and installing the micro-loop probes at the locations shown in the plans.
- e. Preformed Loop Detector shall be securely tied down to prevent the loop from floating during placing of concrete. The pull box end or the conduit shall be sealed to protect against water entrenchment.

4. Additional Cable Quantities. Additional cable quantities shall be installed to provide for slack and the wiring of controllers, feed points, and signal heads as follows:

- a. Nine feet at the controller
- b. Fifteen feet at post-mounted and pedestal-mounted vehicular signal heads
- c. Twelve feet at post-mounted and pedestal-mounted pedestrian signal heads
- d. Eight feet at each pedestrian push button
- e. Fifteen feet at each flashing beacon sign support
- f. Twenty-three feet at each signal pole with mast arm plus the length of the mast arm
- g. Ten feet at the feed point
- h. Five feet at each foundation for each incoming and outgoing pedestrian and signal head control circuit
- i. Six feet at pull boxes where connections are made

- j. Three feet at each foundation for each incoming and outgoing circuit which passes through the foundation with no connection being made.

E. **Pull Box.** Pull Boxes shall meet Section 770.03 F. The top surface of the pull box shall be flush with surfaced areas and approximately one inch above earth or sodded areas. The down side of pull boxes installed on inslopes shall not extend more than 4 inches above the ground.

F. **Installation of Loop Detectors.**

1. **General.** Interruption of the normal flow of traffic shall be the minimum time necessary for installation of the road loop. Work shall not begin until all material, equipment, and personnel are at the site. Barricades, warning signs, and flagpersons shall be placed to protect the workers and the traveling public.
2. **Layout.** The loop location shall be marked on the pavement. The loop shall be placed in the lane for which it was intended, perpendicular to the lane, and to the size shown in the Contract. The Engineer may move the loop location longitudinally to avoid joints, pavement cracks, manholes, and other obstructions. Care shall be taken when moving "presence" and "calling" loop locations so it is not possible for vehicles to stop between loops and go undetected. All loops in a "presence" or "calling" group may require adjustment.
3. **Pull Box Entry.** Conduit shall be installed from the pull box to the gutter or roadway edge as specified. Each loop shall have a separate conduit installed for the pull box entry. The excavation from the saw slot at the gutter or roadway edge shall be made by means of a punch or drill type tool, rather than by usual excavating methods. The visible portion of the gutter shall not be cut for conduit installation. The conduit shall be installed to directly receives the loop wire in line and not at an angle. The hole to receive the conduit shall be at a depth below the roadway surface so there is a minimum of 2 inches of cover on top of the conduit when installed. The top 2 inches of the cover over the conduit hole shall be of the same sealant used to close the saw cut. The conduit and the pull box shall be installed at the same time.
4. **Saw Cut.** The pavement slot shall be sawed with a self-propelled power saw equipped with a depth gauge and alignment guide. The pavement slot shall be cut cleanly and well defined. The saw cut shall be overlapped at all corners and right angle corners shall be cored as shown on the Standard Drawings.

The saw cut may be made at any time before installation of the wire. Slots shall be cleaned immediately after the cutting operation. Wooden strips shall be placed in the cut or a durable cover placed to prevent slot shrinkage or damage before the wire is installed.

5. **Cleaning of Saw Cut.** Before installing the wire, the saw cuts shall be checked for the presence of jagged edges or protrusions, and uneven, jagged edges shall be cut to a smooth line. There should be no cutting dust, dirt, oil, moisture, or other contaminants in the saw cut. Uneven, jagged edges shall be cut to a smooth line.

The sawed slot shall be clean and dry before the wire is installed.

Slots shall be flushed clean by a water stream and dried by an air stream. The blown air from the compressors shall be free of oil and water.

6. **Wire Installation.** Wire shall be installed without damaging the wire or the insulation. Damaged wire shall be replaced at the Contractor's expense.

Wire loops shall be installed without kinks or curls or stretched insulation. All loops shall be wound in the same direction. The beginning and end of the loop in the pull box shall be identified. A constant connection scheme for the color-coded, shielded loop lead-in wire shall be maintained throughout the intersection.

The loop wires from the beginning of the conduit to the pull box shall be twisted a minimum of 5 turns per foot. A minimum of 6 feet of slack for loop wire pairs shall be coiled and left in the pull box.

The wire shall be installed as low in the slot as possible, using a blunt-pointed tool if needed. A sharp-pointed tool shall not be used. The wire shall be held in place with short strips of polyethylene foam sealant backing placed over the wire at approximately every 2 feet. These strips shall be left in place while the sealant is poured. If the wire crosses a crack or joint in the pavement, the conduit shall be installed as shown.

7. **Testing.** Before pouring the sealer, the loop shall be checked for continuity, inductance, and insulation resistance. The test shall be made in the Engineer's presence, and the necessary equipment needed to perform these tests shall be furnished by the Contractor. The Department reserves the right to retest, and these test results shall govern the acceptance or rejection of the loop installation. Tests shall be made as follows:

- a. **Continuity Test.** Each loop detector circuit shall be tested for continuity at 2 locations:
 - (1) Loop detector at the pull box before splicing with the loop detector lead-in cable shall have a value less than 0.5 ohms.
 - (2) Loop detector and lead-in cable system at the traffic signal controller cabinet or detector cabinet after splicing in the pull box shall have a value less than 5 ohms. The continuity test ohm reading at the traffic signal controller cabinet or detector cabinet shall be greater than the ohm reading measured at the loop detector at the pull box.
- b. **Inductance Test.** Each loop detector and lead-in cable system shall have an inductance test measured at the traffic signal controller cabinet or detector cabinet. The inductance shall be in the range of 50 to 500 microhenries.
- c. **Insulation Resistance Test.** An insulation resistance test at 500 volts direct current shall be made at the traffic signal controller cabinet or at the detector cabinet between one loop detector lead-in conductor and the cabinet ground rod. The insulation resistance shall have a value of 100 megaohms or greater.

8. **Saw Cut Seal.** The sealer shall be used according to the manufacturer's instructions.

The sealer shall be poured into the slot to 1/2 depth. When the loop slots are 1/2 filled, the material shall be checked for air bubbles or material pileup. The slots shall then be filled to roadway level. Excess sealant shall be removed.

In no case shall a trough or a mound be formed.

The sealer shall completely surround the wires, displace all air in the cut and completely fill the area except for that portion filled with wire hold-down material. Sufficient time for the sealer to harden shall be allowed (according to the manufacturer's instructions) before traffic is permitted to move over the area.

9. **Final Test.** All tests specified in Section 772.03 F.7 shall be repeated and recorded after installation of the saw cut seal.

All test results shall be recorded in a test report furnished to the Engineer for distribution as follows:

- a. Original to the Construction Division
- b. One copy in the controller cabinet
- c. One copy to the Planning Division
- d. One copy to the Design Division

The loop detector test report shall have the following:

Project Number, Intersection, City, Loop Detector Location, Dimensions (length and width), number of turns, continuity (in ohms) at loop and at cabinet, inductance (in microhenries), and insulation resistance (in megohms).

10. **Detector Feeder Cable Installation.** The loop lead-in conductor shall be installed unspliced from the pull box to the controller. The loop detector system shall be moisture-proof. The loop wire and loop lead-in shall have ends stripped back approximately 5/16 inch. The splice shall be made using insulated pressure type wire connectors. A single coat of adhesive 55-C (Bishop Manufacturing Corp.) or equivalent shall be brushed on. The coat shall cover 1/2 inch of the outer jacket, exposed inner jackets, wire connector, and 2 inches of loop wire insulation. The adhesive coating shall be allowed to dry at least 5 minutes. Each splice shall be wrapped with 3/4 inch "Bi-Seal" Type 3 self-bonding electrical tape or equivalent. A half lap shall start at the center of the splice. The wrapping shall proceed approximately 3/4 inch past the connection end, then back over the connector to 3/4 inch on the other end, and return to the center. The same procedure shall be followed as specified above, covering the previous layer of tape with 3/4 inch "Scotch" No. 88 All-Weather Electrical Tape or equivalent. Both splices shall be wrapped together with 3/4 inch "Scotch" No. 88 Tape or equivalent. The entire splice area shall be covered including adhesive coating applied above. The splice shall be completed by inserting a 4-inch piece of "Scotch" No. 88 Tape or equivalent into the "V" formed by the loop wire.

11. **Loop and Lead-In Conductor.** A wood lath or other nonmetallic material shall be used to hold up the loop and lead-in conductor in the pull box so that the conductor does not touch the bottom of the pull box. The splice area shall be held up at the top of the conductor holding device.

- G. **Feed Point.** All conduits, cabinets, padlocks, conductor, service entrance heads, meter sockets (if required), and ground rods shall be furnished by the Contractor.

All equipment mounted in a switch box of the size shown on the Plans shall be arranged, installed, and wired as required. The local utility company shall be contacted for specific locations of feed points. The utility company will furnish and install the required single phase voltage service connection and any required meter. The Contractor shall lock and/or seal any switch box as required by the utility company or local governmental agency.

The Contractor shall provide and bear all costs for the electrical service necessary to operate and maintain the traffic signal system until the project is accepted by the Engineer.

H. **Traffic Signal Standards and Combination Signal and Light Standards.**

1. A pedestrian push button and sign shall be provided and installed when shown on the Plans.
2. The base, pole, and mast arm shall be painted the color shown on the Plans conforming to Section 772.03 Q. The luminaire mast arm shall be galvanized.
3. All standards shall be plumbed with leveling nuts. The hand hole shall be located away from traffic and the mast arms shall be perpendicular to the roadway centerline.
4. The anchor bolts shall be installed and tightened as specified in Section 754.03 E.5.
5. A rigidly-mounted terminal block shall be provided in the base of each standard, except Type I, for the connection of control circuits. Luminaires shall be fused in the base.

- I. **Traffic Signal and Pedestrian Heads.** Adjustable traffic signal heads shall be mounted vertically. The signal mounting hardware and housing color shall be as specified on the Plans.

Pedestrian signals shall be mounted vertically and shall be mounted within 2 inches of the pole.

The traffic signal and pedestrian head shall be mounted on 1 1/2 inch standard pipe and fittings. The signal and head shall be attached to signal poles using brackets that have threaded pole plates or pole clamps that accept the 1 1/2 inch standard pipe. The pole plates shall be of the type that are held to the pole by means of banding material.

Pedestal-mounted traffic signals and pedestrian heads shall be mounted on a post top slip fitter that attaches rigidly to the signal pole.

Mast arm signal mounted heads shall be rigidly mounted using plumbizers.

All heads shall be effectively hooded with a material that allows the signal heads, when lighted, to be seen dimly by personnel testing the signals. The hoods shall remain in place until authorization is given to operate the signal. The Engineer will determine when the installation is to be put into operation. The heads shall be positioned to provide the best possible view for the traffic to be controlled.

J. Flashing Beacons.

1. **Beacon Head Lens.** The required lens size and color shall be as specified.
2. **Service Poles.** Wooden service poles and the feed point equipment shall be installed as specified.
3. **Mounting.** The beacon heads shall be mounted on span wire and/or sign supports (posts).
 - a. **Span Wire Mounting.** The span wire supporting the beacon head and control cable shall be installed to support the lowest point of the beacon head a minimum of 17 feet and a maximum of 19 feet above the roadway surface. A normal sag of not more than 5% of the total span is permitted. Noncorrosive, 2 inch metal hangers spaced not more than 18 inches apart, or cable wrap in one-foot wide sections 18 inches apart may be used to attach the control cable to the span wire. All overhead conductor shall have an 18 inch drip loop at the service pole.
 - b. **Post Mounting.** The beacon head and conduit shall be attached to a sign support.

K. Pedestrian Push Button Post. The steel post shall be of the specified size, dimension, and color. Paint shall meet Section 772.03 Q.

L. Pedestrian Push Button. Pedestrian push buttons shall be installed at the specified height above ground level.

M. Traffic Signal Controller. The controller cabinet and the direction of the door opening shall be positioned as specified. The signal, interconnect, detector, power, and other circuits shall be connected to the terminals as shown on the manufacturer's wiring diagram. The cabinet shall be mounted as shown on the plans. The Interface Standards Type 1 or Type 2 shall be as shown on the plans.

The cabinets set directly on concrete foundations shall be set on a sealant and sealed with caulking inside and outside of the concrete base.

The field leads shall be neatly dressed to provide orderly arrangement of wires in the cabinet. Field leads shall not be cut shorter than the furthest terminal for the same function in the cabinet. Power conductors, detector lead-in cable conductors, and ground drain wire conductors, etc. shall be properly terminated on the terminal facilities provided for them in the cabinet.

N. Emergency Vehicle Pre-Emption. The emergency vehicle pre-emption equipment shall be installed at the location shown on the Plans. Necessary circuits shall

be connected to the terminals as shown by the manufacturer's wiring diagrams. Time settings shall be determined by preliminary runs conducted by the local jurisdiction.

- O. **Interim Traffic Signals.** Interim traffic signals shall be installed as shown on the Plans. Signal head(s), service poles, span wires, controller, and all other materials and equipment shall be furnished as specified. Service poles of the length shown shall be installed when required.

New signal lamps shall be furnished and installed by the Contractor. All traffic signal lamps for use in 8-inch traffic signals shall be 67 watt. The 12 inch traffic signal head for the "Red" and the stenciled lenses shall use 150 watt lamps, and the remaining 12 inch traffic signal heads shall use 116 watt traffic signal lamps.

Span and stabilization wires, rigid steel conduit, control cable, service poles, and other material shall meet Section 896. The span wire for suspending the traffic control cable shall be attached to the support poles at a level to make the lowest part of any traffic signal not less than 17 feet nor more than 19 feet above the roadway surface. A normal sag of not more than 5% of the total span shall be permitted. Thimble eyebolts, nuts, and washers shall be used to fasten the traffic signal span and stabilization wire to the wood poles.

Noncorrosion metal hangers or cable wrap shall be used to fasten the control circuit to the span wire. The 2-inch diameter metal hangers shall be spaced not more than 18 inches apart. The cable wrap shall be installed in one-foot sections with a maximum of 18 inches between these sections. All overhead conductors shall have an 18 inch drip loop at the junction with a pole.

The controller shall be installed on a wood pole in a manner acceptable to the Engineer.

The Contractor shall furnish and install feed points as shown in the Contract. The power company will make the final service connections.

- P. **Remove Existing Equipment.** The work of removal of existing equipment shall be performed according to the general requirements and to the specific requirements as follows:

1. **General.** Before removing existing equipment, arrangements shall be made for the local utility company to disconnect the power source. When the meter is no longer needed, the local utility will remove it.

The Contractor shall disconnect all wiring to the equipment and completely remove the item from its foundation. The equipment shall be removed without damage and transported to the designated storage site. Any items damaged in removal, transporting, or storing shall be replaced at the Contractor's expense.

The existing foundations shall be removed to a depth of 2 feet below the ground line and the surface restored to match adjacent areas. Foundation removal shall be considered incidental to removal of equipment.

All equipment removed shall remain the property of the Department.

2. **Removal of Signal Heads.** The conductor to the signal heads shall be disconnected. If no new signal heads are to be installed, the disconnected circuits shall be disconnected at the controller terminal strip. The wires shall be taped together and piled in the bottom of the controller cabinet.
3. **Remove Flashing Beacon System.** The Contractor shall remove the feed point after the local utility removes the meter. Beacon heads, controller, and wiring shall be removed from the poles. The poles, span wires, supports, and signs shall also be removed for storage.
4. **Remove Interim Traffic Signals.** Feed point equipment shall be removed from the service pole. The conductor to the signal heads and controller shall be disconnected and removed, and all equipment on the service poles shall be removed. The service poles, span wire, and stabilization wire shall be removed and stored as directed.
5. **Remove Traffic Signal System.** The existing traffic control signal system including the signals, controllers, and feed point shall be removed and stored.

Conductor shall be disconnected, and standard and controller removed. The controller, traffic signal heads, and mounting brackets shall be removed from the standards, and the signal heads shall be removed from the mounting brackets.

The old traffic control cable and concrete foundations shall not be salvaged. These items shall be removed and disposed of at a location acceptable to the Engineer.
6. **Remove Traffic Signal Controller.** The controller cabinet and all controller equipment shall be removed for storage. The foundation shall be removed and the surface of the site restored.
7. **Remove Feed Point.** The switch box, meter trim, and conduit shall be removed for salvage. The local utility will remove the meter.

Q. **Painting.** All equipment installed shall be painted with 2 coats of exterior enamel paint meeting Federal Specification TT-E-489. The color will be specified on the Plans.

The base and lower 12 feet of light standards with attached pedestrian signal heads shall be painted. The signal portion of combination signal and light standards including base, shaft, and mast arm shall be painted.

Application requirements shall be as specified in Section 770.03 Q.2.

- R. **Repairs to Sidewalks and Roadways.** Repairs to sidewalks and roadways shall meet Section 770.03 R and Section 770.04 A.
- S. **Revise Concrete Foundation.** The item "Revise Concrete Foundations" shall require removing concrete from an existing foundation, installing conduit, and replacing the concrete, as specified.
- T. **Tests and Acceptance.** When the installation is complete and at the time designated by the Engineer, an operating test shall be conducted for approval. The Con-

tractor shall furnish instruments and personnel required for all tests, record all test results, and be present during all tests and inspections. Nighttime tests and inspections will be held when directed by the Engineer.

1. **Initial Inspection.** An initial functional inspection shall be made approximately 15 days after all signals under the Contract are operational, except when snow or ice conditions are present preventing observation of installed equipment, or when extreme cold conditions prevent proper observation of equipment operations and adjustments.
 - a. When the above conditions exist, the initial inspection will be delayed. The Engineer will determine when conditions have improved so the inspection can be scheduled.
 - b. During the time of delayed inspection, all signals in operation shall be maintained by the Contractor. When conditions permit initial inspection to be performed, the other inspections will be performed as specified.
2. **Final Inspection.** A final functional inspection will be made 30 or more days after the initial inspection. The final inspection shall not be made until all malfunctions noted on the initial inspection have been corrected. The traffic signals shall be in operation during this time. The Contractor shall maintain the signals during the period between the initial inspection and final functional inspection.
3. **Final Acceptance.** Final acceptance will not be made until the system has been operating for 14 consecutive days after the final inspection without interruption due to malfunctions attributable to defective equipment or improper workmanship.

U. Welding applications as specified in Section 105.06 D.

772.04 METHOD OF MEASUREMENT.

A. **Linear Foot.** These items will be measured by the Linear Foot as follows:

1. **Saw Slot.** Measurement will be made along the saw slot. Saw slot sealant and its installation is incidental to Saw Slot.
2. **Cable Trench.** Measurement will be made along the slope of the ground at the centerline of the trench.
3. **Conduit.** Measurement will be made for each size of conduit. Conduit will not be measured for payment under this item when it is installed in foundations, feed points, overhead and sign-mounted flashing beacons, interim flashing beacons, and traffic signals. The method used to install conduit (such as boring, jacking, or trenching) will not be measured but will be incidental to conduit.
4. **Underground Conductor.** Measurement will be the length of conductor installed including the additional quantities required in Section 772.03 D.4.
5. **Loop Lead-in Conductor and Conductor Cable.** Measurement will be the length of conduit in which the item is installed including additional quantities required in Section 772.03 D.4.

B. **Each.** These items will be measured by the number installed. Separate measurement will be made for each size or type if more than one size or type is installed. These items are as follows:

1. **Concrete Foundations.** Anchor bolts, reinforcing rods, conduit bends, ground rods, and installation and tightening as specified herein will be incidental to the item and will not be measured for payment.
2. **Pull Box.** Conduit for the loop detector item will not be measured and will be considered as incidental to the item.
3. **Feed Point.** The required conduit, cabinets, padlocks, conductors, service entrance heads, meter trim, and ground rods will be considered as incidental to this item.
4. **Signal Standard, Combination Mast Arm Signal, and Light Standard.** The item shall consist of the standard, light standard extension, base, mast arms, fused disconnect, shims or leveling nuts, terminal block, pedestrian push button, painting, and a sign when required.
5. **Flashing Beacon.** The complete unit shall include conduit, conductor, feed point equipment, signal head, span wire, stabilization wire, service poles, and all other items required.
6. **One-Way, 2-Section Pedestrian Signal.** This item shall include connection to internal wiring.
7. **Detector Cabinet.** This item shall include all internal wiring, detector amplifiers, and other equipment required.
8. **Controller.** This item, for Controller Type 1 or Controller Type 2, shall include the cabinet, internal wiring, and other necessary equipment.
9. **Interim Traffic Signals.** This item shall include conduit, conductor, feed point, signal heads, span wire, stabilization wire, service poles, and other necessary equipment.
10. **One-Way Number of Units in Section Head.** This item shall include connection to internal wiring.
11. **Signal Adapter.**
12. **Beacon Head.** This item shall include the push button and sign.
13. **Pedestrian Push Button Post.** This item shall include the push button and sign.
14. **Revise Concrete Foundation.** This item shall include removal, disposal, and replacement of concrete and installing conduit.
15. **Emergency Vehicle Pre-Emption Unit.** This item shall include controller interface, phase selector, optical detectors, detector coupling units, pre-emption indicator lights, optical detector cables, indicator light cables, mounting

and fixtures, and all other items required to complete the emergency pre-emption system in place and in operation.

16. **Microloop probe.** Microloop (single, double or triple) probes shall be measured by the number of single, double or triple probe sets installed. This item shall include the trench, drilling holes, sand, conduits, saw slot, length of conductor from pull box including additional quantities required in Section 772.03 D. 4, and testing loops.
17. **Preformed Loop Detector.** Preformed Loop Detectors will be measured as a unit. This item shall include the conduit and length of conductor including additional quantities required in Section 772.03 D.4.

C. **Remove Existing Equipment.** The following items of removed equipment will be measured by the number of each item removed including disconnecting power, closing wire entrances, removing and disposing of foundations, and transporting and storing equipment removed.

1. Remove Signal Heads
2. Remove Flashing Beacon System
3. Remove Interim Traffic Signals
4. Remove Traffic Signal System
5. Remove Traffic Signal Controller
6. Remove Feed Point

772.05 BASIS OF PAYMENT.

Quantities as provided above will be paid for at the Contract Unit Prices for the several pay items listed on the Plans and in the Proposal Form. This payment shall be full compensation for all labor, equipment, and materials necessary to complete the work.

Payment will be made at Contract Unit Prices for the following:

| Pay Item | Pay Unit |
|---|-----------------|
| Saw Slot | Linear Foot |
| Cable Trench | Linear Foot |
| Conduit ____ Size | Linear Foot |
| Underground Conductor | Linear Foot |
| Loop Lead-in Conductor and Conductor Cable | Linear Foot |
| Concrete Foundations | Each |
| Pull Box | Each |
| Feed Point | Each |
| Signal Standard, Combination Mast Arm Signal, and Light Standard | Each |
| Flashing Beacon | Each |
| One-Way, 2-Section Pedestrian Signal | Each |
| Detector Cabinet | Each |
| Controller | Each |

| | |
|---|------|
| Interim Traffic Signals | Each |
| One-Way Number of Units in Section Head | Each |
| Signal Adapter | Each |
| Beacon Head | Each |
| Pedestrian Push Button Post | Each |
| Revise Concrete Foundation | Each |
| Remove Signal Heads | Each |
| Remove Flashing Beacon System | Each |
| Remove Interim Traffic Signals | Each |
| Remove Traffic Signal System | Each |
| Remove Traffic Signal Controller | Each |
| Remove Feed Point | Each |
| Emergency Vehicle Pre-Emption Unit | Each |
| Microloop (Single) probe | Each |
| Microloop (Double) probe set | Each |
| Microloop (Triple) probe set | Each |
| Performed Loop Detector | Each |
| Controller Type 1 | Each |
| Controller Type 2 | Each |

SECTION 800
MATERIALS

SECTION 895 HIGHWAY LIGHTING

- 895.01 GENERAL
- 895.02 RIGID CONDUIT
 - A. Steel Conduit
 - B. Polyvinyl Chloride Conduit
- 895.03 CONDUCTORS
 - A. Feeders
 - 1. Single Conductors
 - 2. Multiple Conductor
 - B. Internal Conductor
 - 1. Light Standard and Sign Lighting
 - 2. High Mast Lighting Assembly
- 895.04 PULL BOX
- 895.05 FEED POINT
- 895.06 LIGHTING STANDARDS
 - A. Design
 - B. Material
 - C. Mast Arm
 - 1. Davit-Type
 - 2. Truss
 - D. Base
 - 1. Anchor Base
 - 2. Slip Base
 - 3. Steel Transformer Base
 - 4. Aluminum Transformer Base
 - 5. Certification
 - E. Hand Holes
 - F. Convenience Circuits
 - G. Welding applications
- 895.07 STREET LIGHT LUMINAIRE
 - A. General
 - B. Slip Fitter
 - C. Optical Assembly
 - D. Ballast
- 895.08 FUSING
- 895.09 SIGN LIGHTING LOAD CENTER
- 895.10 SIGN LIGHTING LUMINAIRES
 - A. General
 - B. Clamping Mechanism
 - C. Lighting Lamps
 - D. Terminal Block
 - E. Reflector
 - F. Refractor-Door
 - G. Ballast
- 895.11 HIGH MAST SODIUM VAPOR LUMINAIRES

- A. Ballast
- B. Slipfitter
- C. Lamp Socket
- D. Optical Assembly
 - 1. Open Ventilate
 - 2. Enclosed Globe
- E. Symmetrical Luminaires
- F. Asymmetrical Luminaires

895.12 SODIUM VAPOR WALL-MOUNTED LUMINAIRE

- A. General
- B. Housing

895.13 SODIUM VAPOR UNDERPASS CEILING-MOUNTED LUMINAIRE

895.14 HIGH-MAST LIGHTING ASSEMBLY

- A. Design
- B. Shaft
- C. Base Plate
- D. Anchor Bolts
- E. Access Opening
- F. Welding
- G. Certification
- H. Lowering Device
 - 1. General
 - 2. Head Frame Assembly
 - 3. Luminaire Ring Assembly
 - 4. Winch and Hoisting Assembly
 - 5. Cable
 - a. Hoisting Cable
 - b. Winch Cable
 - c. Materials
 - 6. Cable Attachments
 - 7. Portable Power Unit
 - 8. Table IA – Steel Wire Rope Requirements
 - 9. Table IB – Nylon Wire Rope Requirement

SECTION 896 HIGHWAY TRAFFIC SIGNALS

896.01 GENERAL

896.02 RIGID CONDUIT

- A. Steel Conduit
- B. Polyvinyl Chloride Conduit

896.03 CONDUCTORS

- A. Feeders
- B. Loop and Loop Lead-In Conductor
- C. Traffic Signal and Flashing Beacon Control Circuits

896.04 PULL BOX

896.05 SAW SLOT SEALANT

896.06 FEED POINTS

- A. Traffic Signal
- B. Flashing Beacon

896.07 TRAFFIC SIGNAL STANDARDS

- A. General
- B. Type I and II Standards
 - 1. Shaft
 - 2. Transformer Base
 - 3. Type I Signal Standard
 - 4. Type II Signal Standard
- C. Type IV, V, VI, and VII Standards and Combination Signals and Light Standards
 - 1. Shaft
 - 2. Mast Arm
 - 3. Anchor Base
 - 4. Transformer Base
 - 5. Luminaire Extension
 - 6. Miscellaneous

896.08 TRAFFIC SIGNAL HEADS

- A. Standard Units
 - 1. General
 - 2. Housing
 - 3. Lens
 - 4. Lamps
 - 5. Reflectors
 - 6. Visors
 - 7. Backplates
 - 8. Surface Finish
- B. Programmed Units
 - 1. Signal Visibility
 - 2. Lens
 - 3. Lamps
 - 4. Optical Limiter
 - 5. Lamp Fixture
 - 6. Intensity Controller
 - 7. Material Composition
 - 8. Installation
- C. Beacon Head

896.09 PEDESTRIAN SIGNALS

- A. Two Piece Pedestrian Signals
 - 1. Housings
 - 2. Lens
 - 3. Lamp
 - 4. Visors
 - 5. Surface Finish
- B. Programmed Units
- C. Single Piece Pedestrian Signals
 - 1. Housings
 - 2. Lamp
 - 3. Lens
 - 4. Visors
 - 5. Surface Finish

896.10 PEDESTRIAN PUSH BUTTON POST AND BUTTON

896.11 DETECTOR CABINET

- A. Cabinet
- B. Connecting Cable
- C. Cabinet Wiring
- D. Circuit Breakers
- E. Terminal Strips
- F. Finish

896.12 LIGHTNING PROTECTION

- A. Feed Point
- B. Controllers

896.13 CONTROLLER CABINET

- A. Cabinet Design
 - 1. Cabinet Material
 - 2. Cabinet Size
 - 3. Cabinet Style
 - a. Cabinet Door
 - b. Cabinet Items
 - (1) Control Equipment
 - (2) Fan Vent
 - (3) Duplex Receptacle
 - (4) Fused Input for Interconnect Cable
 - (5) Maintenance Switches
 - (A) Stop Time
 - (B) Timer Power
 - (C) Flash
 - (D) Vehicle Detector Input
 - (E) Pedestrian Input
 - 4. Sockets
 - 5. Radio Filters and Surge Protection
 - 6. Additional Load Switches
 - 7. Test Switch
 - 8. Circuit Breakers

896.14 CONTROLLER

- A. General
 - 1. Hardware
 - 2. Load switches
 - 3. MMU unit
 - 4. Remote Flashing
 - 5. Load Switches For Pedestrian
 - 6. Technician Training
- B. Pretimed Controller
 - 1. Controller Requirements
 - 2. Transfer Cycle
 - 3. Time Switches
 - 4. Minimum Controller Features
- C. Actuated Controller
 - 1. Controller Standards

- D. Conflict Monitor
- E. Normal Flashing Operation
- F. Coordination
- G. Interconnect Circuits
- H. Master Controller
- I. External Logic Assembly Unit
- J. Basic Control Equipment Operation for Normal Controller Unit Operation
- K. Traffic Signal Cabinet

896.15 LOOP DETECTOR AMPLIFIERS

896.16 RAILROAD PRE-EMPTION

896.17 EMERGENCY VEHICLE PRE-EMPTION

- A. General
- B. Optical Detector
- C. Optical Detector Cable
- D. Phase Selection Equipment
- E. Reliability
- F. Responsibilities

896.18 SPAN WIRE

896.19 STABILIZATION WIRE

896.20 SERVICE POLE

SECTION 895 HIGHWAY LIGHTING

895.01 GENERAL.

All material furnished shall be new and meet the respective Specifications and standards of the American Institute of Electrical Engineers, Underwriters Laboratories, and the Institute of Traffic Engineers. All electrical parts shall have capacity to carry the required current without heating or causing an excessive drop in potential.

These Specifications shall not be considered as requiring one manufacturer's equipment over any other, provided suitable interchangeability is preserved for maintenance purposes; and equal quality, reliability, and durability can be expected in performance.

The Contractor shall furnish the specified material unless substitute materials are approved in writing by the Engineer.

895.02 RIGID CONDUIT.

- A. **Steel Conduit.** Steel conduit shall be of corrosive-resistant material meeting UL 6. Aluminum conduit shall not be used.
- B. **Polyvinyl Chloride Conduit.** Rigid nonmetallic conduit shall be polyvinyl chloride (heavy wall) conduit meeting UL 651 suitable for direct burial applications.

895.03 CONDUCTORS.

- A. **Feeders.** Conductors used as feeders shall be one of 2 types: a single conductor or multiple stranded conductors formed into a cable. The underground phase and neutral conductors shall be insulated to meet the requirements for direct burial cable carrying currents of up to 600 volts, and shall meet ASTM B-3 and B-8. Aluminum conductor shall not be used.
 - 1. **Single Conductor.** Single conductor shall be marked Style "RHW-USE" with the required AWG size on the sheath. The grounding conductor (not a neutral) shall be stranded No. 6-AWG-Type THW. Rubber insulation specifically listed for that purpose by the Underwriter Laboratories does not require an outer cover.
 - 2. **Multiple Conductor.** Multiple conductor shall be Style USE and meet NEMA Standards Publications WC-3, WC-5, WC-7, rated at 0 through 600 volts, modified as follows:

Multiple conductors shall be of the specified sizes, insulated with either cross-linked thermosetting polyethylene (XLP), or butyl. The multiple

conductors of either insulation type shall have circuit identification. They shall be assembled into a cable of circular cross section with filler, binder, armor, and an overall outer cover. The armor shall be a bronze tape meeting ASTM B-130 with a minimum thickness of 10 mils and a spiral overlap of not less than 1/4-inch. The outer cover on the polyethylene insulated type shall be a polyvinyl chloride material, and the outer cover on the butyl insulated type shall be a neoprene rubber material.

Circuit identification, conductors, cables, fillers, and binders shall meet Part 5 of NEMA WC-3 except that the identification shall be obtained by colored tapes, colored compounds, or colored coatings only, and fillers shall be rubber or rubber-like materials.

B. Internal Conductor.

1. **Light Standard and Sign Lighting.** The conductor connecting the fuse kit in the base of the light standard to the luminaire ballast, or connecting the sign lighting load center to the sign lighting ballast, or connecting the fuse kit in the pull boxes to lighting luminaire ballast shall be copper No. 12 AWG, stranded, Type THWN/THHN, and shall meet ASTM B-3 and B-8. Aluminum conductors shall not be used.

Rubber insulation which has been specifically listed for that purpose by Underwriters Laboratories will not require an outer covering.

2. **High Mast Lighting Assembly.**

- a. **Luminaire Wiring.** The individual luminaire wiring conductor shall be No. 14 AWG stranded, Style THW or RHW-USE, meeting the requirements for carrying currents up to 600 volts. Each luminaire shall be fused within the ballast housing. The fuse shall be rated at 15 ampere and shall be replaceable without tools.
- b. **Power Cables.** The power cable shall be a 4 conductor No. 8 flexible power cord. This cable shall provide a 240/480 volt service. The fourth conductor shall be used as an equipment ground. The end fitting shall be as shown in the Contract.
- c. **Power Cable Protection.** The free hanging static conditions of the cable shall not affect its satisfactory performance and flexibility for a temperature range of -40°F. to 120°F. A bushing or other approved method shall be used to protect the cable from abrasion whenever cable passes through any metal device.

895.04 PULL BOX.

Pull Boxes shall be installed as shown in the Plans.

Concrete pull boxes shall be constructed of Class AE concrete as specified in Section 802.

The pull boxes shall be provided with at least one knockout per side.

895.05 FEED POINT.

The cabinet shall contain a photoelectric cell installed near the top of the cabinets. The cabinet shall have a NEMA 12 rating and be pad or pole mounted. The photoelectric cell shall control the on and off switching of the light circuits and have a 3 to 5 minute delay switch. A pilot relay shall be installed between the photo control and the lighting circuit relays. The lighting circuit relays shall be enclosed and shall normally be in the open position. The cabinet shall have circuit breakers enclosed in a load center type panel board of a type approved for service equipment. The feed point shall have a test switch that bypasses the photoelectric cell.

895.06 LIGHTING STANDARDS.

- A. **Design.** Lighting poles shall meet the requirements of AASHTO publication, *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* (1994). A wind velocity of 85 mph with the necessary coefficient of height correction factor shall be used in the calculations. Different wind pressures shall be applied to the structure at different heights rather than using an average wind pressure for the entire height of the structure. All the necessary calculations and drawings used in the design of these poles shall be furnished with the shop drawing submittal.
- B. **Material.** The light standard shall be fabricated from steel and may be of one or 2 piece construction. All welds shall develop the full strength of the adjacent shaft section. The light standard shall be either galvanized or stainless steel. Galvanized standards, including the mast arm, shaft, and base shall be galvanized according to AASHTO M-111. The round or multi-sided shaft for galvanized steel poles shall have a minimum yield strength of 48,000 psi after fabrication. The multi-sided shaft for stainless steel poles shall have a minimum yield strength of 60,000 psi. The stainless steel shall meet the requirements of ASTM A 666, Type 201 for mast arm, shaft, and base. The shaft shall have no more than one longitudinal weld.
- C. **Mast Arm.**
 - 1. **Davit-Type.** The davit-type mast arm shall be made of the same material as the shaft and shall have a tenon adapter for receiving the luminaire.
 - 2. **Truss.** The truss mast arm assembly shall consist of an upper and lower member securely joined by means of a vertical strut or struts. The upper and lower members shall be steel pipe of 2 inch inside diameter or larger. The pole end of the arm of both members shall have a welded steel fitting for attachment to the pole by cap screws. An opening shall be furnished near the top of the shaft to provide a cable entrance from the shaft into the mast arm. A steel adapter shall be welded into this opening providing a smooth cable guide for wiring and a support for the attachment plate which is welded to the mast arm.
- D. **Base.**
 - 1. **Anchor Base.** The anchor base shall be a one-piece steel casting or hot-rolled carbon steel plate. The steel casting shall meet ASTM A-27, Grade 65-35 and the hot-rolled carbon steel shall meet AASHTO 270 Grade 36. The anchor base shall be secured to the lower end of the shaft by 2 continuous welds. The

welds shall be inside the base at the bottom of the shaft and at the top of the anchor base. The welded connections shall develop the full strength of the adjacent shaft section. The anchor base shall be provided with 4 bolt covers and cap screws for securing the covers to the base. A grounding lug shall be provided if no transformer base is provided.

2. **Slip Base.** The multi-direction slip base shall be of the style and type indicated in the Contract. The plates shall meet AASHTO 270 Grade 36 steel galvanized according to AASHTO M-111. The bolts shall meet ASTM A-325 galvanized according to AASHTO M-232. The keeper plate shall meet ASTM A-466, Grade A and shall be galvanized according to AASHTO M-111.

The manufacturer shall certify that the slip base meets the AASHTO requirements for both breakaway and structural adequacy.

3. **Steel Transformer Base.** The steel transformer base shall be fabricated from not less than No. 7 gauge steel, with the top and bottom plate made of not less than 3/4-inch steel plate. The door opening in the base shall have a tamperproof lock. Each base shall be provided with 4 loose steel plate anchor clips to fasten the base down to the anchor bolts or a base plate fabricated so that leveling nuts and hold down nuts placed on the anchor bolts secures the transformer base to the foundation. After complete assembly, the base shall be galvanized according to AASHTO M-111. The transformer base shall fasten to the shaft anchor base by 4 galvanized hex head steel machine bolts and nuts meeting ASTM A-325, and galvanized according to AASHTO M-232. A grounding lug shall be provided inside the base.

4. **Aluminum Transformer Base.** The aluminum transformer base shall be of the style and type indicated in the Contract. The casting shall meet ASTM B-26 or B-108 Alloy 356-T6. The casting shall be smooth with all details well defined and true to pattern. A grounding lug shall be provided inside the base.

The manufacturer shall certify that the aluminum transformer base meets the AASHTO requirements for both breakaway and structural adequacy.

5. **Certification.** The manufacturer of the stainless steel light standard shall certify that the light standard base meets the AASHTO requirements for both breakaway and structural adequacy when breakaway is called for on the Plans.

- E. **Hand Holes.** Where transformer bases are not to be installed, each shaft shall have a minimum 4-inch by 6-inch hand hole located opposite the road side of the pole. Hand holes shall have reinforcing frames and a secured removable cover.
- F. **Convenience Circuits.** Convenience or Festoon Circuits shall have electrical outlets 15 to 20 feet above ground level. All the material and wiring required for these convenience circuit outlets shall be provided. The outlets shall be wired for 120 volts, 60 Hz., A.C. The outlet box shall be welded inside of the pole, and the outlet cover shall be watertight.
- G. Welding applications as specified in Section 105.06 D.

895.07 STREET LIGHT LUMINAIRE.

- A. **General.** The luminaire shall consist of a die-cast aluminum housing, optical system door, and a door-mounted ballast, and if specified, an internal photoelectric control, finished in backed-on gray enamel.
- B. **Slip Fitter.** The luminaire shall have an adjustable slip fitter containing 2 or 4 bolts, suitable for tightening both internally and externally. The slip fitter shall be capable of adapting to 1 1/4-inch through 2-inch pipe and be adjustable $\pm 5^\circ$ from horizontal.
- C. **Optical Assembly.** The optical assembly shall consist of an anodized aluminum reflector, an adjustable socket assembly, filtered optical system of polyester fiber, a gasket for sealing between the reflector and refractor, and a borosilicate or acrylic polycarbonate prismatic refractor. The light distribution shall be ANSI/IES Type as specified.
- D. **Ballast.** The door-mounted integral ballast shall be quickly and easily removable and replaceable through the use of quick disconnect plugs. The ballast shall be prewired to the lamp socket and terminal board, requiring only connection of the power supply leads to the terminal board. In lieu of door-mounted ballasts, a power pad with easy removal allowing complete ballast assembly replacement by a simple quick-disconnect may be used.

The ballast shall operate one lamp from a nominal (120, 240) volt, 60 Hz. power source and be capable of starting and operating the specified lamp.

895.08 FUSING.

The fusing of the luminaire ballasts shall be accomplished as follows:

- A. Each light ballast shall be fused in the base of each light standard. Connection to power distribution circuits shall be made with field-applied waterproof kits.
- B. Each fused connector kit shall contain a pair of spring-loaded, 90% maximum conductivity contacts suitable for gripping a 15 ampere cartridge fuse. These contacts shall be fully annealed and constructed to be crimped to the cable. They shall be constructed to be retained securely in the proper position within the rubber or molded plastic housing.
- C. Each fused connector kit shall contain a line side and a load side housing, each made of water-resistant synthetic rubber or molded plastic, suitable for burial in the ground or installation in the sunlight. Each housing shall provide a section to form a water seal around the cable; have an interior arrangement to suitably and complementarily receive and retain the copper fuse contacts; and a section to provide a water seal between the 2 housings at the point of disconnection. The load side housing shall be constructed to retain the fuse when disconnected. Each housing shall be permanently marked "loadside" and "line side." Each kit shall be supplied with sufficient silicone compound to lubricate the metal parts and the rubber or molded plastic housing for easy assembly.
- D. Each kit shall be sized for the conductors installed and fused to protect the ballast.

895.09 SIGN LIGHTING LOAD CENTER.

The load center cabinet shall be weather-proof and constructed to receive a padlock. A grounding lug shall be provided inside the cabinet.

895.10 SIGN LIGHTING LUMINAIRES.

- A. **General.** The sign lighting luminaire shall consist of an aluminum main casting containing a clamp mechanism, terminal block, socket assembly, reflector, and a refractor door assembly. The luminaire shall be effectively shielded to oncoming traffic so no direct light is seen by the motorists.
- B. **Clamping Mechanism.** The clamping mechanism shall be designed for a 1 1/4-inch nominal pipe bracket using two 3/8-16 hex-head bolts and serrated, positive gripping, cast aluminum clamps. A vertical adjustment range of $\pm 5^\circ$ shall be designed into the clamping mechanism. Leveling pads shall be provided on the bottom and inside of the luminaire casting.
- C. **Lighting Lamps.** The 250-watt deluxe white mercury vapor sign lighting lamps shall operate on 240 volts A.C. A footcandle uniformity ratio as shown in the Contract, maximum to minimum, shall be obtained on the sign face with the number of sign lighting units per sign as specified. The manufacturer shall certify, through photometric data, that the ratio is obtained.
- D. **Terminal Block.** A terminal block shall be provided under the reflector at the wire entry location. The terminal screws shall be captive to the terminal block. Terminal plates shall be provided for a positive hold action.
- E. **Reflector.** The reflector shall be held in place by 4 screws. Key hole slots shall be provided in the reflector to permit removal without removing the mounting screws.
- F. **Refractor Door.** The refractor-door assembly shall be attached to the main casting by separate hinges at the front of the luminaire and by 2 stainless steel, spring-tempered tension latches at the rear. The spring latches shall provide sealing pressure for the gasketed assembly. The assembly shall consist of an anodized extruded aluminum channel form fitted with captive gasket to the prismatic refractor. The gasket shall be a single piece of high thermal-resistant material, incorporating a sealing pad. The refractor assembly shall be readily removable and capable of being completely immersed for cleaning. The glass refractor shall be protected by a rubber bumper mounted on the pipe bracket.
- G. **Ballast.** The ballast shall be enclosed in a cast aluminum, weather-proof enclosure. The ballast enclosure shall mount directly to the ballast support by four 3/8-inch bolts. The electrical conductor shall enter the ballast by 3/4-inch conduit openings located on each side of the ballast enclosure. The gasketed cover plate shall be attached to the bottom casting by 4 hex head bolts. A 1-1/4-inch threaded pipe shall be provided at the end of the ballast enclosure to support the luminaire.

895.11 HIGH MAST SODIUM VAPOR LUMINAIRES.

- A. **Ballast.** The auto-regulator ballast shall be used with a 1,000 watt sodium vapor lamp. The ballast shall operate at a voltage of 240 volts and it shall be enclosed in a

weather-proof cast aluminum housing fully serviceable without removing the luminaire from its bracket.

- B. **Slipfitter.** The cast aluminum slipfitter housing shall accommodate a 2-inch horizontal pipe bracket and shall be adjustable 3° above and below the bracket axis for leveling. Means shall be provided to prevent the twisting of the luminaire about the bracket. Terminal boards shall be included in the housing.
- C. **Lamp Socket.** The lamp socket shall be a heavy-duty, mogul multiple type, porcelain-enclosed, with an integral lamp grip to assure electrical contact under conditions of normal vibration. Additional lamp clamps shall be provided to help prevent vibrational damage to the lamp and socket. The lamp socket shall be adjustable to provide for different light distributions and maximum candlepower angles.
- D. **Optical Assembly.** The optical assembly may be either an open ventilated unit permitting free flow of air upward by chimney action or an enclosed globe unit. Both symmetrical and asymmetrical distributions may be required. The symmetrical luminaire shall have a maximum beam angle of between 55° and 60°. The asymmetrical luminaires shall have an I.E.S. short, semi-cutoff, Type III distribution.
 - 1. **Open Ventilate.** The open ventilated unit shall be a fully-detachable optical assembly consisting of an annealed borosilicate glass reflector with a sealed metal cover and an open borosilicate glass refractor. The lamps shall have a light center of 8-3/4 inches below the top of the reflector. The effective projected area of a ballasted luminaire shall be approximately 2.7 square feet. The ballast and luminaire shall have a maximum weight of 62 pounds. These specifications shall apply to both the symmetrical and asymmetrical type units.
 - 2. **Enclosed Globe.** The enclosed globe unit reflector assembly shall be of spun aluminum finished with the anodize process. The upper portion shall redirect the reflected light away from the arc tube of the lamp. The assembly shall be enclosed and gasketed and shall contain an activated charcoal filter to allow "breathing." The globe shall be made of heat and shock-resistant tempered borosilicate glass. The globe shall be attached to the reflector housing by a hinged gasketed door with stainless steel latches. The unit shall be constructed to allow the attachment of external shields. The effective projected area of the ballasted symmetrical luminaire shall have approximately 3.2 square feet. The ballasted luminaire shall be a maximum weight of 65 pounds. The effective projected area of the ballasted asymmetrical luminaire shall be approximately 3.4 square feet. The ballasted luminaire shall have a maximum weight of 80 pounds.
- E. **Symmetrical Luminaires.** The symmetrical luminaires shall be Holophane Symmetrical Luminaire, Catalog No. 1171-240 SYM; General Electric Asymmetrical Type X209 High Mast, Catalog No. X209Cl. OL360. Quality Symmetrical Luminaire, Catalog No. 5527-240 or equal.
- F. **Asymmetrical Luminaires.** The asymmetrical luminaires shall be Holophane Asymmetrical Luminaire, Catalog No. 1171-240 ASY; General Electric Asymmetrical Type X209 High Mast, Catalog No. X209Cl. OL3B4 or equal.

895.12 SODIUM VAPOR WALL-MOUNTED LUMINAIRE.

- A. **General.** The luminaire shall consist of a cast aluminum housing containing the ballast, terminal board, and anodized aluminum reflector as well as a cast aluminum door with a heat and impact resistant prismatic refractor sealed to it. The reflector shall have anodized aluminum finish. The refractor shall be a prismatic type of thermal and shock-resistant material. The ballast shall be an integral part of the housing and completely prewired. The socket shall be a mogul base porcelain-grip type with 2 positions for beam control.
- B. **Housing.** The luminaire housing shall be die-cast corrosion-resistant aluminum, completely gasketed to keep out dust, insects, and other contaminants. The ballast area shall have a neoprene gasket and a polyester fiber gasket in the optical assembly for maximum weather-resistant protection. The door assembly shall be hinged to the housing at the bottom, protected by a safety chain and secured by stainless steel latches. The housing shall be constructed to allow installation on any flat surface and shall have wiring holes including a threaded 3/4-inch side entry for exposed conduit.

895.13 SODIUM VAPOR UNDERPASS CEILING-MOUNTED LUMINAIRE.

The mounting system shall protect the enclosed lamp from shock or breakage. The fixture shall be indestructible and guaranteed to withstand vandalism. The fixture shall be for ceiling mounting complete with 100 watt high-pressure sodium lamp, 240 volt high power factor ballast, and neoprene gaskets for outdoor use. The fixture shall also have an unbreakable hercalex opalescent lens diffuser, ultraviolet stabilized for outdoor application, and 14-gauge steel backplates, of baked enamel finish, with stainless steel tamperproof screws.

895.14 HIGH-MAST LIGHTING ASSEMBLY.

- A. **Design.** The design of the high-mast lighting poles shall meet Section 895.06 A.
- B. **Shaft.** The shaft shall be circular or multi-sided and shall be constructed of steel meeting either AASHTO 270 Grade 50, or AASHTO 270 Grade 50 W. The shaft shall have a minimum yield strength of 50,000 psi. The reinforcing material, backup bars (if required) etc., shall meet the same AASHTO steel requirements as the steel in the shaft. The AASHTO 270 Grade 50 steel shaft shall be galvanized according to AASHTO M-111. The AASHTO 270 Grade 50 W steel shaft shall be shot blasted to obtain a uniform finish and allow fast, even oxidation. All exposed surfaces on the AASHTO 270 Grade 50 W steel shall be cleaned of welding slag, loose scale, paint, and grease.

The shaft may be furnished in a single unit or in telescoping sections. If a sectional shaft is furnished, the number of sections shall not exceed 5. Each section shall be fabricated so that each may be telescoped over the next section without the use of welds. The sections shall lap a minimum of 1-1/2 times the outside diameter of the bottom shaft at the location of the lap joint. Telescoping points shall be marked and sections match marked.

The telescoping sections of the shaft, fabricated of AASHTO 270 50 W (Weathering Steel) material, shall be metallized in the overlap areas on both inner and outer

tubes. The metallizing shall meet Section 894.08 A.1.a(2) or (3). The outer joint shall receive a sealant to prevent the intrusion of moisture. The sealant shall be as recommended by the pole manufacturer.

The shaft shall be uniformly tapered from top to bottom.

Each shaft shall be grounded. A grounding nut shall be located within the base.

The internal portion of the shaft shall satisfactorily accommodate the necessary lowering device equipment and shall be free of any obstructions, sharp projections, or protrusions that would interfere with or damage any part of the lowering device.

- C. **Base Plate.** The base plate material shall meet AASHTO 270 Grade 50 or AASHTO 270 Grade 50 W and shall be designed to withstand the full bending moment of the shaft. AASHTO 270 Grade 50 W steel shall be shot blasted to allow fast, even oxidation.

The enlarging of anchor bolt holes to provide for the possible shifting of the anchor bolts will not be allowed.

- D. **Anchor Bolts.** Anchor bolts shall meet the mechanical requirements of AASHTO M-31, Grade 75 or ASTM A-576, Grade 1541 modified or equal. The exposed portion of the bolt above the foundation shall be galvanized according to AASHTO M-232. Precaution shall be taken against embrittlement, warpage, and distortion according to ASTM A-143.

Each anchor bolt shall have 2 extra-heavy, high-strength hex nuts, one for leveling and one for hold down. The hex nuts shall be galvanized according to AASHTO M-232 and meet ASTM A-143 for prevention of embrittlement. The nuts shall make full contact with the base plate.

Anchor bolts shall be shipped before the rest of the equipment and shall be preclustered, or clustered by mechanical rings which can be field-assembled. A removable template shall be supplied to ensure proper fit of the pole base on the anchor bolts.

The manufacturer shall certify that the anchor bolts are of adequate strength to resist the required loading. They shall be of sufficient length to develop the required loading of the bolt. Adequate thread length shall be provided. Anchor bolts shall not be welded to meet the required lengths.

- E. **Access Opening.** Access openings of ample size allowing for service and maintenance of internal apparatus shall be provided near the base of the shaft. The opening shall not interfere with the operation of the lowering device.

Openings shall be externally reinforced to provide 150% of the unaltered shaft section modulus beginning and ending at a distance of 1/4 shaft diameter above the top and 1/4 shaft diameter minimum below the bottom of the access openings or internally reinforced to return the shaft to its full strength.

Covers with stainless steel cap screws and a hand grip shall be furnished to secure the opening. The cover shall be furnished with gaskets that will seal out dust, rain, and snow.

- F. **Welding.** All welding shall meet AASHTO, Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, and Section 616.03 D.

Each shaft section shall have a maximum of 2 longitudinal seam welds, except that the bottom 2 sections shall have a maximum of 3 longitudinal seam welds. Shafts with 2 or 3 seam welds shall have a minimum of 80% penetration, while shafts with only one longitudinal seam weld shall have a minimum of 60% penetration. Longitudinal welds at slip joints shall have 100% penetration. No circumferential welds will be allowed.

Full penetration-type welds shall be made for the shaft to base plate welds. Backup bars are permitted; however, they shall be contoured for full contact with the shaft, be continuous, and be of the same material as the shaft. Backup bars shall not be tacked to the shaft. All spaces between the backup bars and the shaft shall be filled with molten lead.

All attachment welds shall be full penetration fillets. Field welds will not be permitted.

All welds shall be visually inspected to check that there are no cracks, undercutting, or surface blow holes. In addition, all welds shall be ultrasonically and/or magnetic particle tested. Records of welding procedure and all test results shall be submitted to the Engineer.

Full penetration-type welds shall be made in the overlap area. These welds shall be radiographically examined in an area consisting of the overlap plus an additional 6 inches of tube length. Any deficient welds shall be repaired and then retested after repairs are made.

- G. **Certification.** The manufacturer shall certify that all joints and welds of the assembled structure, when loaded as specified in these Specifications, will develop the full strength of the shaft.

Certification shall also be submitted that deviation of the shaft alignment or “canting” will not occur at any of the joints when erected.

H. **Lowering Device.**

1. **General.** The lowering device shall lower the luminaire ring to within approximately 4 feet (vertical) of the base plate. The luminaire ring assembly shall be capable of being raised or lowered at a minimum rate of 10 feet per minute. All cables, both electrical and hoisting, shall be able to be inspected from ground level. The complete lowering system shall consist of a head frame assembly which is rigidly attached to the top of the pole shaft, a luminaire ring assembly on which the luminaires are mounted, and a winch and hoisting assembly which is located in the base of the pole shaft.
2. **Head Frame Assembly.** The head frame assembly shall include a minimum of 4 hoist cable sheaves grooved to exact cable diameter for 180° cable bearing surface and 1 or 2 grooved power cable sheaves. The sheaves shall have oil impregnated, sintered bronze bushings over the stainless steel shaft. Sheaves shall be the only moving components of this assembly. Sheave pins

shall not be welded but shall be secured by washers and cotter keys or pins. The sheaves shall have a minimum diameter of 25 wire rope diameters for the positive locking load cable system; except when 2-point suspension and 2 winches are used, the sheaves minimum diameter shall be 24 wire rope diameters. For nylon-jacketed wire rope, the wire rope diameter used shall be the core or unjacketed wire rope diameter.

The electrical and support cables and sheaves shall be arranged to minimize their exposure. Openings into the shaft shall be minimized by a cover plate or other suitable means to reduce water intake, yet permit adequate shaft ventilation.

The assembly shall provide for a 2- or 3-point suspension of the luminaire ring. Structural members shall be of stainless steel, or galvanized steel according to AASHTO M-111.

Where the structural members have been welded together to form a reasonably weather-tight head frame assembly, the only openings shall be the holes through which the hoisting cables and the power cables pass.

The head frame shall be securely fastened to the shaft in an approved manner.

Should the Contractor use the option of holding the luminaire ring in place by latching devices, the head frame assembly shall include 2 or 3 latching devices to support the raised luminaire ring. All moving parts of the latch mechanism shall be attached to the luminaire ring assembly and shall be serviceable from the ground. The latching mechanism shall not be impaired by the formation of ice. All tension and weight shall be removed from the hoisting cables when the luminaire ring is latched to the head frame assembly. Means shall be provided to indicate the luminaire ring is latched to the head frame.

3. **Luminaire Ring Assembly.**

- a. **Slipfitters.** The slipfitters for the mounting of the luminaires shall be of 2-inch steel pipe. The slipfitters shall be attached to the luminaire ring either by being threaded into welded hubs or by bolts. A suitable smooth wire entrance shall be provided in each slipfitter when the slipfitter is attached by U-bolts.
- b. **Ring.** The ring shall serve as a fully-enclosed wire raceway for all electrical connections to the luminaires. The ring may be factory prewired or field wired.
- c. **Assembly.** The assembly, except where noted, shall be hot-dipped, galvanized according to AASHTO M-111.
- d. **Power Receptacle.** A weather-tight, twist-type lock, power receptacle shall be provided on the ring to allow for the testing of lamps and ballasts while the ring is in a lowered position. Two 10-foot sections of pole power cable shall be provided for the testing. Each section shall be provided with electrical connections to connect the power source to the ring.
- e. **Roller Arms.** A minimum of 3 steel spring-loaded centering roller arms shall guide the luminaire ring when it is raised or lowered. The arms shall

be stainless steel or aluminum. The springs shall be stainless steel. Rollers shall be made of a water-resistant nonmarking material. A PVC bumper ring may be utilized in lieu of roller arms.

- f. **Luminaire Ring.** The luminaire ring shall be of adequate size, strength, and shape to accommodate the number of luminaires per pole as specified.

When in a raised position, the luminaire ring shall have no free movement. When in a raised position, the luminaire ring assembly may be held in place by the constant load cable system or by a positive latching device which shall not be impaired by accumulation of snow or ice.

If a constant loading cable system is used, a backup cable and grip system shall be provided to prevent free fall of the luminaire ring if a winch cable failure occurs. Minimum 1/4-inch diameter stainless steel aircraft cable shall be provided.

The luminaire ring assembly shall be equipped with an approved lightning arrester and shall be installed in an approved electrical manner. The line leads of the arrester shall be spliced to the hot power cable conductors within a junction box. The ground lead of the arrester shall be connected to the ground conductor of the power cable at which point a positive ground connection is made with the luminaire ring. This positive ground may be accomplished by a grounding lug attached to the luminaire ring but not to the junction box. All splices and connections shall be internal to the system and not exposed to the elements. The arrester furnished shall be securely attached to the junction box or the ring.

The junction box shall contain all splices required for connecting the power cable to the individual luminaire wiring.

4. **Winch and Hoisting Assembly.**

- a. **Lowering Device.** The 3-cable lowering device shall be a self-locking, worm-gear type with a permanently lubricated gear box. The 2-cable lowering device winch assembly shall consist of a worm-gear speed reducer with a double output shaft and with stainless steel drums with calibrated spring-loaded clutches which compensate for possible hoist cable overrun. The minimum drum diameter of the winch shall be 16-wire rope diameter for the positive locking system and 20-wire rope diameter for the cable system, except when 2 winches are used, the minimum drum diameter shall be 14-wire rope diameters.

The maximum allowable stress in the sheaves, pins, drums, brackets, and other associated structural members of the lowering device shall not exceed 1/2 of the nominal yield stress of the material. The winch drum shall contain at least 3 full wraps of wire rope when the luminaire assembly is in the fully-lowered position. The starting end of the wire rope shall be securely attached to the winch drum through use of a suitable clamp or "keyhole and stop" arrangement. Drum flanges shall be large enough to contain the winch cable and provisions made so the winch cable does not build up on the end of the drum and run off.

On “Positive Locking System,” when the load is removed from the cable after the luminaire assembly is locked in place, provisions shall be made to prevent the winch cable from loosening on the drum to an extent that cables cross each other.

All bolts and machine screws shall be secured to preclude their becoming loosened by vibration. Star washers, jam nuts, self-locking nuts, locking compound, etc., may be used to secure nuts and machine screws.

- b. **Winch.** The permanent winch assembly shall be internally mounted in the pole base. The winch shall normally be operated by an electric drill; however, the winch shall be adaptable to manual operation.

The winch shall be capable of being removed from the pole without having to make electrical disconnects or mechanical manipulations.

- c. **Circuit Breaker.** A circuit breaking switch and a twistlock disconnect shall be provided in the pole base. There shall be no electro-mechanical disconnect at the pole top. The switch shall be used to switch power on and off to the main power cable for the lowering device and the portable power cable. There shall be facilities to energize the luminaires and ballasts while the luminaire ring is in a lowered position. The circuit breakers shall be 30 amps, single throw, double pole mounted in a 100 amp frame.
- d. **Torque Limiter.** A current or torque limiter shall be provided to shut down the drill whenever the luminaire ring is seated in the head frame assembly.

5. Cable.

- a. **Hoisting Cable.** The hoisting cables shall be a minimum 3/16 inch diameter, 7 x 19 stainless steel cable. When hoist cables are used as winch cable, they shall be 1/4 inch diameter 7 x 19 stainless steel cable.

The 2 or 3 cables attached to the luminaire ring shall be equally spread.

Hoisting cables utilized in the constant load cable system shall be nylon jacketed, unless they are used, as winch cables.

- b. **Winch Cable.** The winch cable shall be a minimum 1/4 inch diameter, 7 x 19 stainless steel cable. When the luminaire ring is in a raised position, this cable shall be wound on the winch drum.
- c. **Materials.**

- (1) **Stainless Steel.** Material for stainless steel cables shall meet the following composition:

| | | | |
|-------------|-------------|----------|---------------|
| Carbon | 0.15% max. | Sulfur | 0.030% max. |
| Manganese | 2.00% max. | Chromium | 17.0% – 20.0% |
| Silicon | 1.00% max. | Nickel | 8.0% – 12.0% |
| Phosphorous | 0.045% max. | | |

(2) **Nylon-Jacketed Cables.**

The nylon jacketing material shall be extruded over the rope. Only virgin nylon material shall be used to coat wire ropes. The nylon used on the wire rope shall meet the following requirements of Federal Specification MIL-2-83420:

| Property | Test Value |
|---------------------------|---------------------------------|
| Ultimate Tensile Strength | 5000 psi min. |
| Elongation | 250% min. |
| Specific Gravity | 1.02 to 1.14 psi min. |
| Stiffness | 35,000 psi min. |
| Water Absorption | 1.5% max. |
| Brittleness | −65°F. (−54°C.) max. |
| Heat Deflection | 110/45°C. at 66/264 psi min. |
| Melting Range | 320°F. to 374°F. |
| Burn Resistance | 4-inch/min. |

- (3) **Lubricant.** A suitable type of friction-preventive compound having non-corrosive properties shall be impregnated into the wire rope.

- (4) **Wire.** The wire used in steel cable shall be cylindrical and smooth and of uniformly high quality. It shall be free from splits, cold shuts, and other defects.

Tensile strengths of wire and wire sizes shall be such that wire rope will be capable of meeting the requirements of this Specification.

The individual wires and strands composing the wire rope shall be shaped into the exact helical position they will have in the finished wire rope. If the wire rope is cut or severed, the measured diameter of the wire rope at the unseized cut ends shall not increase by more than the amount specified in Table IA.

All wire splices or joints shall be brazed or welded. Any joints in individual wires in any layer of a strand shall not be closer than 20 feet.

The type of construction for the respective diameters, the dimensional tolerances, and the physical properties shall be as specified in Table IA.

- (5) **7 by 19 Construction.** Wire ropes of this construction shall consist of 6 outer strands of 19 wires each laid around a core strand of 19 wires. The 6 outer strands shall each consist of a layer of 6 wires laid around a center wire in a left-hand direction and a layer of 12 wires laid over the 7-wire strand in a left-hand direction. The core strand shall consist of a layer of 6 wires laid around a center wire in a right-hand direction and a layer of 12 wires laid around the 7-wire strand in the right-hand direction. The 6 outer strands shall be laid around the core in a right-hand direction. The length of lay of the inside layer of 6 wires in each of the 6 outer strands and the one core strand shall not exceed 60% of the lay of the outside layer of 12 wires in each strand. The length of the lay of the outside layer of 12 wires in each of the 6 outside strands and the core strand shall not exceed 50% of the lay of the finished wire rope. The length of the lay of the finished wire rope shall be not more than 8 times nor less than 6 times the nominal wire rope diameter.

Other wire rope construction may be used to improve the operation of the Hi-Mast Lighting Unit if the other conditions of the Specifications are met, i.e., design factor, stretch limits, sheave and drum ratios. In such cases, the manufacturer of the wire rope shall certify it meets the specific design application.

- (6) **Wire Quality Testing.** Quality conformance testing shall consist of all the inspections such as workmanship and physical appearance specified. The sample wire rope shall pass the breaking strength test and all samples shall be subjected to the stretch tests.
- (a) **Sampling.** When conducting the tests herein, one sample shall be taken after any discard has been removed from the head or starting end of the first manufacturing reel for each lot of wire rope. A lot shall consist of not more than 20,000 feet of wire rope of the same construction and diameter produced continuously by one machine or by one series of progressive processing machines.
 - (b) **Workmanship.** The finished cable shall be uniform in construction and securely laid, free from kinks, loose wires, loose strands, or other defects.
 - (c) **Nylon-Jacketed Cables.** The nylon coating shall be a uniform thickness as specified in Table IB and shall be uniform in appearance. The nylon coating shall be transparent and shall be homogeneous and uniform in consistency. The jacketed wire rope shall have no cracks or seams, or extrusion die marks on the surface which affect wire rope performance. Any deleterious effects, such as cracking or separating from the wire rope, shall be cause for rejection.
 - (d) **Breaking Strength.** The wire rope specimen shall be selected from the sample from each lot. The specimen shall be no less than 24 inches in length, and where necessary, swaged terminals meeting Federal Specification MIL-T-781 (do not use

ball-end fittings) and accompanying hardware may be used to facilitate installation of the specimen in the jaws of the testing machine. The distance between the jaws of the testing machine with the sample shall be no less than 10 inches. The breaking strength shall be determined by use of a tensile testing machine according to ASTM E-8. The breaking strength shall meet the requirements of Table IA for qualification.

- (e) **Stretch Test.** One specimen from each sample of wire rope selected as specified shall be tested to determine the percent stretch. The total length of the wire rope specimen to be tested shall not be less than 24 inches. Where necessary, swaged terminals and accompanying hardware may be used to facilitate installation of the specimen in the jaws of the test machine. The amount of stretch shall be determined on a tension-testing machine according to ASTM E-8. The specimen shall be loaded to 1% nominal breaking strength shown in Table IA to straighten the wire rope. While the specimen is under tension, an adequate gauge length shall be marked off the wire rope between the jaws of the testing machine. The specimen shall then be loaded to 60% of minimum breaking strength and measured to elongation under load. The specimen so tested shall not exceed a stretch of 1.5%.
- (f) **Responsibility for Inspection.** The supplier shall perform all inspection requirements. The supplier may use its own or any other suitable facilities for the performance of the inspection requirements, if approved by the Engineer.
- (g) **Certification.** The wire rope manufacturer shall furnish a certified test report showing that the wire rope meets this Specification. The test report shall include actual results of the tests.

The nylon certification and test report shall be furnished by the manufacturer.

- 6. **Cable Attachments.** Wire rope attachments which are not readily accessible for inspections shall be permanently swaged onto the cables by the wire rope manufacturer in accordance with the recommended practice of the fitting manufacturer. These end attachments will generate the full nominal break strength of the cable.

Adjustable or semi-permanent end attachments such as wire rope clips shall be attached in a manner and of a number recommended by the fitting manufacturer. No less than 2 clips of correct size shall be used on each termination, and clips shall be inspected and retightened as necessary. The "saddle" portion of the clips shall bear on the live or long end of the cable and the U-bolt shall bear on the dead or short end of the cable.

All eyes (loops) shall be thimbled to protect the wire rope from abrasions.

No wire rope attachments shall be applied over nylon jackets of cables.

- 7. **Portable Power Unit.** The portable power unit shall supply all necessary driving power to the winch.

The minimum 1/2-inch heavy-duty, reversible electric drill with a torque limiter shall operate on 240 volts. A means of checking the restraint offered by the torque limiter shall be provided.

The drill shall be provided with overload protection and be UL approved. The drill shall be arranged for remote control operation. A drill mounting assembly shall be easily attached to the base of the pole with a quick-connect securing mechanism that can accommodate any size or shape pole. A pendant control switch with a 20 foot cord shall be provided to allow the operator to stand clear of the service area while the luminaire ring is either raised or lowered. Two drills shall be provided.

8.

TABLE IA
Construction, Physical Properties of Galvanized Carbon Steel
and Stainless Steel Wire Rope

| Nominal Dia. of Wire Rope (In.) | * Const. | Tolerance on Dia. (Plus only) (In.) | Allowable Inc. of Dia. (In.) | Nominal Break Strength Galv. Carbon Steel (Lbs.) | Nominal Break Strength Stainless Steel (Lbs.) | Approx. Wt. per 100 ft. (Lbs.) |
|--|-------------|--|---------------------------------------|---|--|---|
| 5/32 | 7 x 19 | .016 | .017 | 2,800 | 2,400 | 4.50 |
| 3/16 | 7 x 19 | .018 | .019 | 4,200 | 3,700 | 6.50 |
| 7/32 | 7 x 19 | .018 | .020 | 5,600 | 5,000 | 8.60 |
| 1/4 | 7 x 19 | .018 | .021 | 7,000 | 6,400 | 11.00 |
| 5/16 | 7 x 19 | .022 | .024 | 9,800 | 9,000 | 17.30 |
| 3/8 | 7 x 19 | .026 | .027 | 14,000 | 12,000 | 24.30 |

*See Section 895.14 H.5.c.(5)

9.

TABLE IB
Construction and Dimensional Properties of
Nylon Jacketed Wire/Rope Jacket Tolerances

| Nominal Dia. of Wire Rope (In.) | * Const. | Tolerance on Jacket O.D. (Plus only) (In.) | Outside Dia. of Jacket (In.) | Jacket Wall Thickness (Reference) (Lbs.) | Approx. Wt. per 100 ft. (Lbs.) |
|--|-------------|---|---------------------------------------|---|---|
| 3/16 | 7 x 19 | .022 | 5/16 | .063 | 9.20 |
| 7/32 | 7 x 19 | .020 | 9/32 | .031 | 9.76 |

*See Section 895.14 H.5.c.(6)(c)

SECTION 896

HIGHWAY TRAFFIC SIGNALS

896.01 GENERAL.

The word and phrase definitions shall be as defined in Section 1 "Definitions" of NEMA Standards Publication TS 2 latest edition *Traffic Control Assemblies with NTCIP Requirements*.

These Specifications shall not be considered as requiring one manufacturer's equipment over any other, provided suitable interchangeability is preserved for maintenance purposes and equal quality, reliability, and durability can be expected in performance.

The word and phrase definitions shall be as defined in Part 1 "Definitions" of NEMA Standards Publication TS-1 latest edition *Traffic Control Systems*.

The Contractor shall furnish the specified material unless substitute materials are approved in writing by the Engineer.

All hardware and software shall process dates and date-related data accurately prior to, during and after the year 2000. This will include accurately inputting, storing, manipulating, comparing, calculating, updating, recording, displaying, outputting and transferring such dates and data.

896.02 RIGID CONDUIT.

- A. **Steel Conduit.** Steel conduit shall be of corrosive-resistant material meeting UL 6. Aluminum conduit shall not be used.
- B. **Polyvinyl Chloride Conduit.** Rigid nonmetallic conduit shall be a polyvinyl chloride (heavy wall) conduit meeting UL 651 suitable for direct burial applications.

896.03 CONDUCTORS.

- A. **Feeders.** Conductors used as feeders shall be one of 2 types: a single-stranded conductor or multiple-stranded conductors formed into a cable. The underground phase and neutral conductors shall be insulated to meet the requirements for direct burial cable carrying currents of up to 600 volts, and shall meet ASTM B-3 and B-8. Aluminum conductors shall not be used.

Single conductor shall be marked Style "RHW-USE" with the required AWG size on the sheath. The grounding conductor (not a neutral) shall be stranded No. 6-AWG-Type THW. Rubber insulation specifically listed for that purpose by the Underwriter Laboratories does not require an outer cover.

- B. **Loop and Loop Lead-In Conductor.** The conductor shall meet one of the following:
 1. The copper loop conductor shall be No. 14 AWG, Type XHHW or THWN or THHN single-stranded 600 V conductor or as recommended by the detector manufacturer.
 2. Polyethylene Conduit Pre-wired shall consist of a pliable polyethylene conduit with No. 14 AWG stranded copper Type XHHW or THWN or THHN 600 V conductors. The conductors shall be factory assembled in a continuous flexible polyethylene conduit. The conduit shall be constructed from 1/4-inch black polyethylene meeting ASTM D-1248, Type III, Grade P33 or E10, Category 5, Class C, and shall be certified to meet or exceed the following values:

NOMINAL DIMENSIONS OF POLYETHYLENE CONDUIT IN INCHES

| | |
|-------------------------|-------------|
| Duct Size | .250 |
| Outside Diameter | .250 ± .010 |
| Wall Thickness | .032 ± .010 |
| Nominal Inside Diameter | .185 |
| Minimal Bending Radius | 1.00 |

NOMINAL PHYSICAL PROPERTIES OF POLYETHYLENE CONDUIT

| Property | Test Value | ASTM Test |
|---|--------------|-------------------|
| Tensile Strength @ yield, psi | 3,200 min. | D-638 |
| Ultimate Elongation, % | 400 min. | D-638 |
| Melt Index, gms/10 min. | 0.5 max | D-1238 |
| Carbon Black Content, % | 2.00-3.00 | D-1603 |
| Density of Base Resin, gms/cc. | 0.941-0.959 | D-1505 |
| Brittleness Temperature, F ₂₀ | -75°C., max. | D-746 |
| Environmental Stress Crack Resistance, F ₂₀ | 48 hrs. | D-1693 Cond. B |

The conduit shall also meet or exceed the performance tests as specified in NEMA Standards Publication No. TC7, Part 3 as follows:

- a. TC7-3.01 Compressions and Recovery
- b. TC7-3.02 Impact Test

The conduit shall be permanently marked on the outside at regular intervals with the manufacturer's name, trademark, nominal conduit diameter, Type III, and year of manufacture.

3. The copper loop lead-in conductor shall be a No. 14 AWG stranded polyethylene insulated twisted pair with a foil shield or as recommended by the detector manufacturer, and shall be able to be placed in a common conduit with power and control circuit cable without interference.

The jacket shall be a Hi density polyethylene jacket with a nominal thickness of 0.032 inches.

4. **Preformed Loop Detector.** The Performed Loop Detector shall be constructed of PVC and loop conductor. The loop detector shall be totally encased in 1/2" schedule 40 PVC, (sprinkler pipe, heavy wall construction) with pipe fittings and glue. One corner shall be terminated with a 1/2" PVC tee fitting to provide an exit to the pull box conduit. The PVC is to be sealed at the joints with water pipe fitting glue to prevent water entrenchment. The conductor shall be No. 14 AWG, Type XHHW or THHN or THWN, 600 V stranded single conductor. The loop shall be constructed from a continuous piece of conductor with no splices throughout the entire length to the pull box. Three turns shall be placed in the preformed loop. The conductor from

the loop to the pull box shall be twisted to provide a minimum of two to five turns per foot.

5. **Microloop Probe:** The microloop probe shall be a small, cylindrical, passive transducer of earth's vertical magnetic field intensity into inductance. It transforms changes in magnetic field intensity into inductance changes which can be sensed by loop detector units. Probes shall fit vertically in 1" holes and lead-in cable in 3/8" saw slot or in sand in the roadway base. Micro-loop probes can be connected in series with other microloop probes or conventional wire loops. The microloop probe shall operate under the following parameters: Earth's Vertical Magnetic Field (0.2 to 1.0 oersted), Inductance (20 microhenries to 25 microhenries per probe plus 20 microhenries per 100' of wire), DC Resistance (0.5 ohms per probe plus 3.2 ohms per 100' of wire) Transducer Gain (typically 3.5 microhenries per oersted at 0.4 OE ambient vertical field intensity), and Sensitivity with 2 probes (7.0 microhenries per oersted at 0.4 OE ambient vertical field intensity). The microloop probes shall operate at a temperature range of -35°F to +165°F (-37°C to +74°C) and at humidity of 0 to 100%. The microloop probes shall detect all motorized vehicles.

- C. **Traffic Signal and Flashing Beacon Control Circuits.** The cable required for the signal control circuits shall consist of No. 12 AWG multiple conductor cable. The Pedestrian push button circuit shall consist of No. 16 AWG multiple conductor cable. The cables shall be rated for 600 volts and meet NEMA Standard Publication WC-5.

The conductor shall be Class B or Class C stranded copper, and the insulation shall be polyvinyl chloride or polyethylene. The thermoplastic insulation over the individual conductors shall consist of a minimum thickness of 30 mils, of which a minimum of 20 mils shall be polyethylene and the remaining thickness either polyvinyl chloride or extruded nylon. Where cable has been approved as THWN/THHN conductor, the conductor and the thermoplastic insulation over the individual conductors shall consist of a minimum thickness of 19 mils, of which a minimum of 15 mils shall be polyvinyl chloride with the remaining thickness of nylon.

Circuit and cable identification, cable fillers, and binders shall meet Part 5 of NEMA WC-5, except as modified here. The color coding of conductors shall meet Appendix K, Method I, Table K-1 of NEMA WC-5. All fillers shall be of a moisture-resistant material, and shall not be jute. Binder tapes shall be of a moisture-resistant material.

The jacket shall be polyvinyl chloride with the thickness meeting Table 7.4.2, NEMA WC-5.

896.04 PULL BOX.

Concrete pull boxes shall meet Section 895.04.

896.05 SAW SLOT SEALANT.

The joint sealer shall be made of a material mixture to form a resilient and adhesive compound capable of effectively sealing the saw slot. The seal shall protect against

infiltration of moisture and foreign material throughout repeated cycles of expansion and contractions with temperature changes. Also, the sealing compound shall not flow from the joint or be picked up by vehicle tires at summer temperatures. The material shall be capable of being brought to a uniform pouring consistency for completely filling the saw slot without large air holes or discontinuities and without damaging the material. An epoxy-type sealant will not be permitted.

896.06 FEED POINTS.

A. **Traffic Signal.** A traffic signal feed point shall also include:

1. A 60 amp size switch box.
2. One manually operated weatherproof switch, 2 pole, single throw, 125/250 volt with 45 ampere cartridge fuses, or breakers.

B. **Flashing Beacon.** A flashing beacon feed point shall also include:

1. A 60 amp size switch box.
2. One manually operated weatherproof switch, 2 pole, single throw, 125/250 volt with 15 ampere cartridge fuses, or breakers.
3. Both a Radio Interference Filter (RIF) and a Surge Voltage Protector (SVP) shall be supplied for use on the 120 VAC supply. Each shall be rated at nominal 120 volts, 60 Hz., and a minimum of 30 amps and in no case be less than the current rating of the circuit breaker protecting it. There may be one RIF and one SVP protected by a common main circuit breaker before the 120 VAC supply is split into the automatic and flash circuit breaker branch circuits, or a separate RIF and SVP may be used after each pole of the automatic and flash circuit breakers.
4. The flasher shall be solid state and meet NEMA Standards Publication No. TS 2, latest edition, Traffic Controller Assemblies with NTCIP Requirements, Section 6.
5. Where the flashing beacon is to be a school crossing beacon, a solid state time clock shall be installed. The solid state time clock shall have, as a minimum, the following capabilities:
 - a. Automatic daylight savings time and leap year compensation.
 - b. A minimum of 48-hour battery or capacitive backup-memory and timing maintained in event of power loss.
 - c. A minimum of 6 program steps programmable to one-minute intervals.
 - d. Operate on a line voltage of 95–135 Volts AC, 60 Hz.
 - e. Temperature range of –30 °C to +74 °C.
 - f. Liquid crystal display.
 - g. Single Pole, Double Throw (SPDT) output relay rated 10 Amp, 115 Volt AC resistive load.

- h. Terminal block for electrical connection that will accommodate wire sizes #16 – #12 AWG.
- 6. A weatherproof cabinet with a lock and 2 keys shall be of adequate size to mount circuit breakers, on-off switch, flasher, time clock (if required), and all necessary wiring. This cabinet is not required when the Plans specify that the flasher shall be placed in a feed point cabinet.

896.07 TRAFFIC SIGNAL STANDARDS.

A. **General.** The design of the Traffic Signal Standards shall meet the requirements of AASHTO publication, *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* (1994). A wind velocity of 85 mph with the necessary coefficient of height correction factor shall be used in the calculations. The wind loads, allowable stresses, etc., shall meet these Specifications. Different wind pressures shall be applied to the structures at different heights, rather than using an average wind pressure for the entire height of the structures. All necessary calculations and drawings used in the design of these standards shall be furnished with the shop drawing submittal. The support structure shall be designed to support the mast arm signals and signs, if required.

B. Type I and II Standards.

1. **Shaft.** The shaft shall be made of standard steel seamless pipe meeting AASHTO M-183 or ASTM A-53; or the shaft shall be made of standard aluminum pipe meeting ASTM B-429, Alloy 6061-T6, or 6063-T6. The shaft shall be 4-1/2 inches in outside diameter, with one end threaded for connection to the base. The design stresses for the shaft shall be calculated at the root of the thread.
2. **Transformer Base.** A transformer base of adequate strength, shape, and size shall be secured to the lower end of the shaft. The shaft shall be tightened securely in the base. The base shall be provided with 4 holes to receive the anchor bolts, a handhole, and a grounding lug on the inside of the shaft or base. The grounding lug shall be opposite the handhole and a locking device shall be included for the handhole cover. All details of the bases shall be well-defined and true. Design stresses shall be calculated at the root of the thread or thinnest wall section. The material shall meet ASTM A-27 Steel, or ASTM B-26, or B-108 Alloy 356-16 Aluminum. All necessary mounting hardware shall be furnished.
3. **Type I Signal Standard.** This standard shall be used to mount traffic signal controller cabinets and detector cabinets. The combined height of shaft, base, and cabinet shall be a maximum of 6 feet to the top of the cabinet.
4. **Type II Signal Standard.** This standard shall be used as the pedestal for pedestrian signals. The overall height of the shaft and base shall be 8 feet.

C. Type IV, V, VI, and VII Standards and Combination Signals and Light Standards.

1. **Shaft.** The shaft shall be round or multi-sided, made of steel that has a minimum yield strength of 48,000 psi after fabrication. The wall thickness shall

be a minimum of 0.179-inch for Types IV, V, VI, and VII shafts, and 0.239-inch for the combination light and signal shaft. The shafts shall be tapered with top and bottom diameters large enough to withstand their design load. The Type V, VI, and VII shafts shall have a top outside diameter of 4-1/2 inches for a post top slipfitter, and the combination light and signal shaft shall be 2-piece construction.

2. **Mast Arm.** The truss mast arm shall have both lower and upper members securely joined by vertical struts. These members shall have a minimum wall thickness of 0.119 inch, and shall have a minimum yield strength in excess of 48,000 psi after fabrication. The monotube mast arm shall be round or multi-sided. The mast arm shall have a minimum wall thickness of 0.179 inch, and shall have a minimum yield stress of 48,000 psi after fabrication. Only one longitudinal weld and no transverse welds shall be permitted in fabricating the mast arm. The signal mast arm shall be designed to be rotated away from the roadway without disconnecting signal circuits or removing the mast arm.
3. **Anchor Base.** The anchor base shall be a one-piece steel casting or hot-rolled carbon steel plate. The steel casting shall meet AASHTO M-103, Grade 65-35. The anchor base shall be secured to the lower end of the shaft by 2 continuous welds. One weld shall be inside the base at the bottom of the shaft, while the other shall be on the outside of the shaft at the top of the anchor base. The welded connection shall develop the full strength of the adjacent shaft section.
4. **Transformer Base.** The steel transformer base shall be the size specified by the manufacturer to support the shaft and mast arm. It shall have a yield strength in excess of 33,000 psi after fabrication. The transformer base shall be fastened to the shaft anchor base by 4 galvanized hex-head machine bolts and nuts meeting AASHTO M-164, galvanized according to AASHTO M-232. There shall be a door opening opposite the street side of the transformer base, secured in place by an approved locking device.
5. **Luminaire Extension.** The shaft extension for mounting the luminaire shall be designed the same as the rest of the shaft. The galvanized steel extension shall have a minimum wall thickness of 0.119 inch and shall have a minimum yield strength of 48,000 psi after fabrication. The extension shall be galvanized according to AASHTO M-111. The stainless steel extension shall have a minimum wall thickness of 0.721 inch and have a minimum yield strength of 60,000 psi. The stainless steel shall meet the requirements of ASTM A 666, Type 201. The shaft shall be tapered with a bottom and top diameter of sufficient size to withstand the design loads. The extension shall be designed to provide for mounting a street light luminaire at a specific height above the pavement.
6. **Miscellaneous.** Connections, brackets, banding, wiring entrances, etc., shall be according to the manufacturer's specifications. Mast arm signals shall be designed for a rigid mounting of traffic signals. All hardware used in assembling the traffic signal standard base or mast arm shall be galvanized according to AASHTO M-232. A grounding lug on the inside of the base shall be provided.

896.08 TRAFFIC SIGNAL HEADS.

A. Standard Units.

1. **General.** The design of the signal head shall allow the addition of a signal section with the aid of simple tools and the addition of certain standard parts. All signal heads, lamps or a light-source using Light Emitting Diodes (LED) shall conform to the latest standards of the Institute of Transportation Engineers. All exposed screws and fasteners shall be 1808, Type 304 stainless steel.
2. **Housing.** The housing of each section shall be one-piece corrosion-resistant aluminum, aluminum alloy die casting, or a one-piece polycarbonate resin material complete with integrally cast top, bottom, and sides. The polycarbonate housing shall be at least 0.090 inch thick, and shall be ribbed with at least 2 vertical ribs in addition to ribs on the top and bottom surfaces. Reinforcement plates shall be furnished and installed to reinforce the bottom of the signal head when rigidly mounted on a pedestal-type signal standard. Two sets of internal bosses shall be provided in each section for horizontal mounting for a terminal block. The top and bottom exterior shall be flat to assure perfect alignment of assembled sections. Individual signal sections shall be fastened together either with machine screws between each section or by the 3 bolt and 2 washer method. The housing door of each signal section shall be a one-piece corrosion-resistant aluminum, alloy die casting, or polycarbonate resin material.
3. **Lens.** The circular lens shall be standard Red, Yellow, Green, or special stenciled design. The polycarbonate lens shall meet ASA D-10.1, UDC 656.057 or revisions thereof. The colors of vertically mounted lens shall be positioned as specified in MUTCD. Each 8-inch lens shall have a nominal diameter of 8 inches with an outside diameter of from 8-5/16 inches to 8 3/8 inches. Each 12-inch lens shall have a nominal diameter of 12 inches with an outside diameter of from 11-15/16 inches to 12-1/32 inches.

The Contractor may choose to furnish signal heads using circular lenses using either incandescent lamps as a light source or a LED light source. He may provide a combination of signal sections using circular lenses using incandescent lamps as the light source and/or LED as a light source.

The manufacturers shall certify that the ITE specifications are met. These certifications shall be supplied with the shop drawings.

4. **Lamps.** All traffic signal lamps for use in 8-inch traffic signals shall be 67 watt, and shall have a light center length of 2-7/16 inches.

The 12-inch traffic signal head for the "Red" and the stenciled lens shall use a 150 watt traffic signal lamp with a light center length of 3 inches. The remaining 12-inch traffic signal heads shall use 116 watt traffic signal lamps with a light center length of 3 inches. The LED signal module shall fit into the traffic signal housing built to the Equipment and Materials Standards of the Institute of Transportation Engineers (ITE).

5. **Reflectors.** The reflectors shall be either of silvered glass or anodized aluminum or other material that is equal to or exceeds the standards of ITE Technical Report No. 1, latest revision.

6. **Visors.** Visors shall be corrosion-resistant aluminum alloy or polycarbonate resin and shall be of the tunnel type. All signal heads shall contain an anti-sun phantom feature.
7. **Backplates.** Five-inch backplates shall be provided with all signals and shall be aluminum. The backing plates shall be painted dull black. They shall have louvered openings to reduce wind load.
8. **Surface Finish.** All surfaces shall be finished with 2 coats of baked enamel. The finish coat shall be oven-baked and shall meet Federal Specification TT-E-489. The door and visors shall be painted dull black. The polycarbonate units shall have the required color molded in.

B. Programmed Units.

1. **Signal Visibility.** The lens's color position shall be erected and placed in position meeting the position requirements of MUTCD, and the colors of the signal projected shall meet the ITE Transmittance and Chromaticity Standard. The signal unit shall be designed to project the desired signal so it can be seen only by the lane of traffic it controls. The design shall permit the projected image to be seen or veiled from view anywhere in an area up to 15° on either side of the centerline of the projected image. The signal shall not be activated by any other light source such as an adjacent signal. Further, the signal unit shall be capable of showing 2 images at one time from any one signal head, such as a green arrow over the green ball within a definite measured distance from the signal light.
2. **Lens.** The unit shall be made of a high resolution plane incremental lens hermetically sealed within a flat laminant of weather resistant acrylic or approved equal. The lens shall be symmetrical so it can be placed in any position in a 90° arc around its axis without affecting the image projected through it.
3. **Lamps.** The lamps shall be 150 watt, 120 volt A.C., 3-prong stripped sealed beam with built-in reflector and shall have an average life of at least 6,000 hours. The lamp shall be attached to a diffusing element that has a collar with a specular inner surface.
4. **Optical Limiter.** There shall be an optical limiter that projects the signal image to a distance of 900 to 1,200 feet, and provides a veil or mask that can be applied to limit visibility of the image to a specific lane of traffic. The limiter shall be made of heat resistant glass.
5. **Lamp Fixture.** The lamp fixture shall be an indexed ceramic socket, self-aligning, quick-release lamp retainer with a housing and lamp support that is easily accessible. The electrical connection between the case and lamp housing shall be an interlock assembly that disconnects the lampholder when opened. Each signal section shall have a covered terminal block for clip or screw attachment for the lead wires. Concealed No. 18 AWG stranded and coded wire shall be used to interconnect all sections to allow field connection to any section.
6. **Intensity Controller.** Each signal section shall include integral means for regulating its intensity based on background illumination. The lamp intensity

shall be at least 97% of the uncontrolled intensity at 1,000 foot candles, and shall reduce to $15 \pm 2\%$ of the maximum at less than one foot candle. The response shall be proportional and essentially instantaneous to any detectable increase of illumination from darkness to 1,000 footcandles, and damped for any decrease from 1,000 foot candles. The intensity controller shall be comprised of an integrated, directional light-sensing and regulating device interposed between lamp and line wires. It shall be compatible with the 60 Hz input and responsive within the range of 105 to 135 volts. The output may be phase controlled, but the device shall provide a nominal terminal impedance of a 1,200 ohms open circuit and corresponding holding current.

7. **Material Composition.** Die cast aluminum parts shall meet ITE alloy and tensile requirements and have a chromate preparatory treatment. The exterior of the signal case, lamp housing, and mounting flanges shall be furnished with a high quality baked enamel prime and finish paint. The lens holder and case interior shall be optical black. The signal case and lens holder shall be predrilled for backplates and visors. The backplates, visors, and batten plates, shall be painted dull black. The hinge and latch pins shall be stainless steel. All access openings shall be sealed with weather-resistant rubber gaskets. Sheet metal parts including visors and backplates shall meet ITE material requirements, and shall include a chromate preparatory treatment.
8. **Installation.** The signal shall mount to standard 1 1/2-inch fittings. The signal section shall be provided with an adjustable connection that permits incremental tilting from 0° to 10° above or below the horizontal while maintaining a common vertical axis through couplers and mounting. The terminal connection shall permit external adjustment about the mounting axis in 5° increments. The signal shall be mountable with ordinary tools and capable of being serviced with no tools. Attachments such as visors, backplates, or adapters shall conform and readily fasten to existing mounting surfaces without affecting water and light integrity of the signal.

- C. **Beacon Head.** Each beacon head shall consist of a single section traffic signal head conforming to this Section. The fittings shall be standard traffic signal bracket fittings as specified by the manufacturer.

896.09 PEDESTRIAN SIGNALS.

A. Two Piece Pedestrian Signals.

1. Housings.

- a. **Signal Housing.** The incandescent pedestrian signal shall be a 2 section DONT WALK and WALK type. The upper section shall display the DONT WALK symbol and the lower section shall display the WALK message.

The signal shall be dust-free and weather-tight. It shall have molded gaskets between all component parts. All screws, fasteners, and metal parts shall be stainless steel.

The 2 sections shall fit rigidly and securely together without a spacer. All sections shall be identical and interchangeable. The signals shall be de-

signed for mounting on standard 1 1/2-inch signal brackets. The 2 sections shall be fastened together as specified by the manufacturer.

Each rectangular section shall be a one-piece corrosion-resistant aluminum alloy die casting; or a one-piece polycarbonate resin material complete with integrally cast top, bottom, and sides. The housing shall be of substantial thickness and shall be ribbed. Two sets of internal bosses shall be provided in each section for horizontal mounting or terminal strip facilities. Each section shall have an integrally-cast, serrated locking ring which will permit the rotation of the signal head in 5° increments. Two hinge pin openings shall be located on the left side of each housing, and 2 noncorrosive inserts shall be internally located on the right side of each housing.

- b. **Reflector Housing.** The reflector housing shall be a corrosion-resistant aluminum alloy die cast or a polycarbonate resin material. The reflector shall be anodized aluminum or other material that equals or exceeds the standards of ITE Technical Report No. 5, latest revisions.
2. **Lens.** The lens shall be mounted in a continuous neoprene gasket, which completely encompasses the edge of the lens and provides a cushion and positive seal between the lens and the door. The lens and the gasket shall be secured to the door by 4 lens clips.

The legend of the prismatic glass lens shall be fired in, or shall be raised letters on the inside. The polycarbonate lens shall have a smooth surface on the outside and a diffusing surface on the inside. The WALK indication shall be lunar white and the DONT WALK indication shall be Portland orange, both meeting the ITE Standards. All of the lens surface except the letters shall be obscured by an opaque material. When not illuminated, the WALK and DONT WALK messages shall not be visible to pedestrians at the far end of the crosswalk they control. The light source shall be designed and constructed so that in case of an electrical or mechanical failure of the word DONT, the word WALK of the DONT WALK message will also remain dark. The nominal 9-inch rectangular lens shall have letters 3 inches high and the nominal 12-inch rectangular lens shall have letters 4-1/2 inches high. All strokes shall meet ITE Standards.

3. **Lamp.** The lamp socket shall be the prefocused type for holding a traffic signal lamp. This socket shall prevent the lamp from working loose due to vibration. The lamp receptacles shall be weatherproof molded construction and shall withstand, without deterioration, the temperatures encountered during operation.

All traffic signal lamps for use in the 9-inch pedestrian signals shall be 67 watt and shall have a light center length of 2-7/16 inches.

All traffic signal lamps for use in the 12-inch pedestrian signals shall be 150 watt and shall have a light center length of 3 inches.

4. **Visors.** The visors shall be corrosion-resistant aluminum alloy or polycarbonate resin, and shall be the tunnel type. All signal heads shall contain an anti-sun phantom feature.

5. **Surface Finish.** All surfaces shall be finished with 2 coats of oven-baked enamel. The final coat of the door and visors shall be painted dull black. Paint shall meet Federal Specification TT-E-489. Fastening devices shall not be painted. The polycarbonate units shall have the required color molded in.

B. **Programmed Units.** All preceding functional requirements for programmed signal heads and general design requirements for pedestrian heads shall apply for these pedestrian signal heads, with the exception that 75 watt lamps shall be used and lamp dimmers shall not be required.

C. **Single Piece Pedestrian Signals.**

1. **Housings.**

- a. **Signal Housing.** Pedestrian signal heads shall consist of a single piece cast aluminum housing and door, a single piece double parabolic polycarbonate reflector, a single piece glass lens with two color message, a blankout z-crate type visor, appropriate sockets, bulbs, and other related hardware. The design shall present an assembly that has good appearance, easy to maintain, and is energy efficient.

The optical system shall consist of the reflector, lens, bulbs, sockets, and visor. The optical system shall be designed to minimize sun phantom while giving a clear, unmistakable message to the pedestrians using the crosswalk area. Persons outside the crosswalk area shall receive either a limited view or be altogether prohibited from viewing the signal message.

- b. **Reflector Housing.** The reflector shall be formed from a single piece of .25-inch thick textured polycarbonate sheet. The lamp side of the reflector shall be the textured side and shall be reflectorized with vacuum deposited aluminum coating protected by a hard wear resistant coating. A sheet aluminum divider shall be installed between the two message sections to prevent light spill between the sections.
2. **Lamp.** The lamp sockets shall be mounted directly to the aluminum housing to provide a rigid mounting and proper heat sinking. The reflectors shall have appropriate holes top and bottom to provide adequate heat dissipation. With proper air circulation and heat sinks, there shall be no deformation or degradation of the reflector, lens, or other parts of the signal.
3. **Lens.** The lens shall be .187-inch thick tempered glass with the legend and colors applied and bonded to prevent any peeling or cracking. The lens shall be located at least 1.75 inches from the closest glass bulb envelope to prevent heat damage to the lens.
4. **Visors.** The visor shall be fabricated from .040 inch thick black polycarbonate strips to form a geometric grid consisting of 1-inch bisected diamond patterns. The message surface of the lens shall be totally shaded when the sun is more than 22° above horizontal and at least 50% shaded if the sun is 8° or more above horizontal. The visor assembly shall be physically rugged in both material and construction to minimize damage by vandals. The visor assembly shall be fastened to the door with stainless steel screws and shall not protrude beyond the front of the door casting.

5. **Surface Finish.** The signal housing and mounting hardware shall be painted the color as shown in the Contract.

896.10 PEDESTRIAN PUSH BUTTON POST AND BUTTON.

The steel post shall meet AASHTO 270 Grade 36. The post shall be provided with a means to attach the pedestrian push button and sign, and it shall have a post cap.

The push button shall be of tamperproof construction. The assembly shall be weatherproof. It shall be constructed so an electrical shock cannot be received under any weather condition. The housing shall be constructed of die-cast aluminum.

The pedestrian push button shall be raised from or flush with their housings and shall be a minimum of 2 inches in the smallest dimension. The force required to activate the push button shall be no greater than 5 lbf.

896.11 DETECTOR CABINET.

- A. **Cabinet.** The detector amplifiers shall be housed in a gasketed, dustproof, weatherproof cabinet of neat design and appearance made of a satisfactory grade of aluminum or sheet steel. The door shall be of the same material as the housing, mounted on hinges, and shall allow full access to the interior of the cabinet. It shall have a lock with 2 keys provided. The cabinet shall be large enough to provide ample space to house all equipment specified. A satisfactory vent or ventilating device shall be provided at the top of the cabinet to minimize condensation and provide a means of escape for any gases encountered. Each cabinet shall be provided with a mounted lamp receptacle and lamp, a grounded electric outlet, and a suitable shelf for holding detector amplifiers.

Live or hot parts of any electrical equipment inside the cabinet shall be protected. Electrical equipment, terminal facilities, etc., shall be mounted on metal liners (not plywood or other material) and attached to the backwall of the cabinet. The metal liners shall be attached to the backwall of the cabinet. If screws are used to mount the metal liners, the screws shall be tamperproof.

- B. **Connecting Cable.** The connecting cable for the amplifiers shall be laced out of the cabinet wiring harness to permit the amplifier unit to be placed on the shelf within the cabinet. The connecting cable harness shall be flexible to -30°F .
- C. **Cabinet Wiring.** Cabinet wiring shall be neat and firm. Assemblies and panels shall be easily accessible for maintenance purposes. Backwired assemblies of panels shall be mounted and wired to provide accessibility to the backwiring.
- D. **Circuit Breakers.** Two surface-mounted main circuit breakers with no backwire connections shall be provided. One breaker shall carry the load for the detector amplifiers, and the other breaker shall carry the load for the lamp receptacle and the electrical outlet. The breakers shall be single pole, 120/240 volt, 60 Hz., and 15 ampere base load. The breakers shall be conveniently located on one of the inside sidewalls on the cabinet. Each circuit breaker shall be clearly marked with "ON" and "OFF" position, and identified with the load which it is carrying (AMPL. and CONV. OUTLET).
- E. **Terminal Strips.** The detector cabinet terminal strip consisting of sufficient individual point terminal blocks for all external field terminals shall be provided.

Each terminal block shall be a solid (not sectional) one-piece plastic molding with point terminals, with minimum 1/4 inch barriers or of sufficient height to prevent lugs from shorting to adjacent terminals with normal terminal connections. Blocks shall be sized according to load with a minimum size 15 amp signal load, a minimum 50 amp power distribution board, and a minimum 20 amp on all others. The terminal screws shall not extend through the plastic, and the slots shall be of sufficient size to fit the spade-type lugs. The terminal strips shall be individually numbered so there are no duplicate numbers. Numbering shall be on a marker strip or a mounting plate beside each terminal attached to each terminal block. All terminal lugs shall be correctly sized to fit the terminals.

A separate terminal strip interface panel for terminating all amplifier connecting cable leads shall be provided. Each terminal shall be fully insulated with 6-32 binder head screws on the front side. The terminal blocks shall be rated 20 amperes, 300 volts. The number of terminal blocks shall be determined by the total number of required terminations. Terminal strips for equipment AC connections and cabinet ground shall be provided. The equipment ground terminals shall be copper buss-type terminal with set screw-type terminals (not washer head screw-type), or a terminal block of solid (not sectional) one-piece plastic molding with 10-32 size binder head screws not extending through the plastic, and the slots shall be of sufficient size to fit the spade-type lugs. The equipment AC connections shall be made of the copper bus-type terminals with set screw-type terminals (not washer head screw-type).

- F. **Finish.** The cabinet and mounting brackets shall be painted with 2 coats of enamel. Care shall be taken that no gasketing is sealed until the paint is dry. All hinges, locking nuts, etc., shall be free and operate easily without damage to the gasketing after the paint work is completed.

896.12 LIGHTNING PROTECTION.

- A. **Feed Point.** A lightning protection device shall be installed on the feed point incoming lines to prevent lightning surges entering through the wiring from damaging electrical wiring and control equipment in the solid state pretimed or traffic-actuated controller cabinets. The protector shall be a sturdy, weatherproof, service-proven device that immediately drains lightning surges harmlessly to ground. The protector shall be installed on the switch box and shall discharge a surge in a fraction of a second. It shall perform this protective function over and over again, without any maintenance required, possessing the same long-life, value-type characteristics obtained in higher voltage distribution arrestors.

The protector shall be a 2-pole, 3-wire device designed for single-phase 120/240 volt 3-wire grounded neutral service. The protector shall be mounted in the knockout in the switch box. All leads shall be tinned copper No. 14 AWG.

The protector shall be capable of:

1. Limiting the surge voltage to 3 KV peak, while;
2. Conducting surge currents of at least 10 KA with an 8 by 20 microseconds (time to crest by time to second half-crest) waveform; and
3. Recovering to its former state after the surge is over with AC power applied.

The manufacturer of the AC suppressor shall certify that the suppressor meets ANSI C621.1/IEEE, Standard 28, paragraphs 7.1 and 7.6. The suppressor peak voltage shall not exceed 3 KV when tested according to paragraphs 7.3 and 7.5 of the ANSI/IEEE Specification.

The AC line surge protector shall be installed on the load side of the circuit breaker. If the protector should fail and short the circuit, the circuit breaker shall open to give maximum protection. The AC neutral shall have the same protection as the AC load. The arrester leads shall be kept as short as possible. Grounds shall be made directly to the cabinet wall or ground plate as near as possible to the object being grounded. An acceptable arrangement is shown on the Plans.

If the AC power is brought into the cabinet via an underground conduit, a similar arrangement shall be followed as shown on the Plans. If the conduit is metallic, it shall be connected to the ground rod as shown on the Plans.

Connections from the ground rod to the objects inside shall be made with AWG No. 8 (or larger) copper wire.

B. Controllers. A lightning protection device shall be installed at each interconnect wire terminal connection on the cabinet terminal strip as shown on the Plans. A lightning protection device shall also be installed on the incoming power lines to prevent lightning surges entering and damaging electrical wiring and control equipment. The protection device shall do the following:

1. Clamp the surge to as low a voltage as possible, ideally to about twice the peak operating voltage of the circuit being protected.
2. Be capable of conducting a surge current of at least 1,000 amperes at an 8 by 2 microseconds waveform without damage to itself.
3. Be capable of dissipating at least 40 joules of energy without damage to itself.
4. Be capable of suppressing 6 surges in rapid (1 second) succession as described in 1, 2, and 3 above without degradation of performance.

Interconnect line suppressors shall be installed as close as possible to the point where the lines enter the controller cabinet. Surge suppressors packaged in one unit may be utilized in place of the individual arrangement shown on the Plans if the suppressors meet the performance requirements listed above. In either case, the suppressor leads shall be kept as short as possible.

896.13 CONTROLLER CABINET.

A. Cabinet Design. The control cabinet shall meet the requirements of NEMA TS 2 Traffic Controller Assembly with NTCIP Requirements Section 7, except as follows:

1. The steel cabinet shall be painted with 2 coats of aluminum paint meeting Section 852.01A. Care shall be taken that no gasketing is sealed until the paint is dry. All hinges, lock nuts, and any other moving parts, shall be free and operate easily without damage to the gasketing after paint work is complete. Cabinets that are constructed entirely of aluminum need not be painted.

2. The base mounted cabinet shall be sized to provide space for the housing of all equipment specified as well as future coordination equipment. The minimum dimensions of the cabinet shall be 52 inches high, 44 inches wide, and 24 inches deep.
3. The cabinets shall have a cover to block air flow in cold weather. A metal weatherproof cover shall be provided to adequately cover the fan vent assembly and the louver on the door. The cover shall be gasketed and attached to the inside of the cabinet. The cover shall be of the same material as the cabinet and shall be finished the same as the cabinet.
 - a. A weep hole shall be provided in the bottom loop on each end of the cabinet full-size door for water drainage. The cabinet full-size door shall open to the LEFT or RIGHT as shown in the Contract.
 - b. The cabinet shall contain, among others as required, the following items:
 - (1) All items of control equipment specified in these Specifications.
 - (2) A thermostatically-controlled minimum 250watt strip-type finned heater shall be provided and mounted on the full-size door cover and shall have a protective wire-mesh shield installed around the heater. A heavy-duty thermostat, such as a Penn Central A19-BAB-3 or equal shall be used. Power to the fan and to the heater shall be activated by a 3-position toggle switch located on the auxiliary switch panel. The switch shall operate vertically up and down with the up position being FAN (power to the fan shall be on and power to the heater shall be off); the center position being OFF (power to both the fan and the heater shall be off); and the down position being HEATER (power to the heater shall be on and power to the fan shall be off). An electrical 3-prong twist lock-type plug shall be provided between the switch and the heater so the heater can be easily removed. The heater thermostat shall be mounted on the auxiliary switch panel. Connection to the heater shall be made with stranded copper wire having 200°C. insulation and noninsulated, solderless terminals.
 - (3) Duplex receptacle with ground fault interruptor, lamp base with switch. Outlet and lamp to be fused ahead of the main circuit breaker.
 - (4) Fused input for interconnect cable complete with MOV surge protection.
 - (5) Maintenance switches inside the cabinet shall include the following:
 - (a) Stop time control.
 - (b) Timer power.

- (c) Flash.
 - (d) Vehicle detector input for each phase in use and all future phases.
 - (e) Pedestrian input for each phase in use and all future phases.
4. Load switches and flasher with number of sockets as shown in the Contract shall meet the requirements of NEMA TS2 Traffic Controller Assembly with NTCIP Requirements Section 6 and shall include switches and flashers for future phases.
 5. Two radio interference filters and surge protectors, each rated at nominal 120 VAC, 60 Hz., and minimum 30 amp or greater based on load, with one filter and surge protector in the main automatic operation circuit and the other in the main flashing operation circuit.
 6. In addition to the number of solid-state load switch units required to operate the intersection, one spare solid-state load switch unit, separately packaged and marked, shall be provided and stored in the cabinet.
 7. Pushbutton detector test switches shall be provided in the controller cabinet for placing calls for vehicular and pedestrian phases for testing purposes.
 8. The cabinet shall contain 2 surface-mounted main circuit breakers with no back wiring. One breaker shall carry the load during automatic operation and the other breaker shall carry the load during flashing operation. The breakers shall be single pole, 120/240 volt, 60 Hz., and 30 maximum ampere based on the load. If the signal circuit load during automatic operation exceeds 30 amperes, a 3-pole common trip circuit breaker with 30 ampere rating for each pole or a single 60 amp breaker shall be used on that circuit. The signal bus load shall be split and equally divided between the 2 poles. If the flash load exceeds 30 amperes, a 30 ampere 2-pole breaker with split flash shall also be used on that circuit. Each circuit breaker shall be clearly marked with "ON" and "OFF" positions and identified with the load which it is carrying ("AUTO" or "FLASH").

896.14 CONTROLLER.

- A. **General.** The controller shall be a solid state unit and shall have front panel access to display cycle length, offset, and internal timing values. Access to these timing functions shall be by keyboard entry as an integral part of the controller. The controller shall meet NEMA environmental and electrical performance standards. The display shall be a liquid crystal display (LCD) and contain a minimum of 4 lines with 40 characters per line. The display shall have a 16 range adjustment of contrast control and backlighted which automatically turns off 10 minutes after the last key is depressed. The display and keyboard shall be functional over the NEMA temperature range of -34°F. to +165°F.
 1. Hardware for future pedestrian signals shall be provided when shown.
 2. The controller shall be equipped with solid state signal load switching devices meeting current NEMA requirements. Load switches shall be furnished with indicator lights on the front panel.

3. Each controller shall be furnished with a malfunction manager unit (MMU) conforming to NEMA performance standards.
4. The controller shall be furnished with extra feature wiring to provide for remote flashing and each wire shall have its own terminal connection. The flash control circuit shall ensure that remote transfer to flashing from normal stop and go operation occurs during the No. 1 interval in the cycle. When the controller is in flashing condition, the signal switching mechanism shall be inoperative.
5. Load switches for pedestrian indications shall be required when pedestrian indications are shown. The cabinet wiring, load switch sockets, and connection facilities shall be included for pedestrian movements permissible with phasing shown.
6. The Contractor shall provide a technician trained in the operation of the controller to provide training to others at the time of signal activation. The technician shall be available for at least two consecutive days.

B. Pretimed Controller.

1. The controller furnished shall meet current NEMA TS 2 Traffic Controller Assemblies with NTCIP Requirements. The plans shall show Type 1 or Type 2 to be used at the intersection.
2. Transfer from one cycle to another shall to another shall occur only at the beginning of the first interval in the signal sequence. Indiscriminate transfer anywhere in the first interval shall not be allowed.
3. Time switches shall be solid state and provide control of selected signal functions. Manual switches for selecting normal controller functions shall be provided in the controller cabinet and be of the type compatible with traffic control function requirements. The manual switches shall have skip day capability and battery backup for continuous operations for at least 72 hours during power failure. When the manual switches require mounting to the cabinet wall, they shall be mounted on the inside of the cabinet door.
4. The controller shall have, as a minimum, the follow features:

| | |
|--------------------|--------------------|
| 3 cycle lengths | 1 signal plan |
| 2 splits per dial | preempt capability |
| 3 offsets per dial | 2 actuated inputs. |

C. Actuated Controller.

1. The controller furnished shall meet current NEMA TS 2 Traffic Controller Assemblies with NTCIP Requirements. The plans shall show Type 1 or Type 2 to be used at the intersection.

896.15 LOOP DETECTOR AMPLIFIERS.

The loop detector amplifiers specified shall meet NEMA TS 2 Traffic Controller Assemblies with NTCIP Requirements.

The loop detector amplifier shall be self-tuning meeting Section TS 1-15.2.20.2 of NEMA Standards, Part 15.

896.16 RAILROAD PRE-EMPTION.

All equipment and material required for this feature shall be included in the controller cabinet. The rack switch for activating the railroad pre-emption shall normally be closed.

896.17 EMERGENCY VEHICLE PRE-EMPTION.

A. **General.** The controller shall have, when shown in the Contract, a system in which the traffic control signals may be pre-empted by emergency vehicles. The emergency vehicle pre-emption system shall consist of the controller interfacing (if required), phase selectors, optical detectors, detector coupling units, pre-emption indication lights, optical detector cables, mounting and fixtures, and all other miscellaneous items required to complete the emergency vehicle pre-emption system in place and in operation. The indicator light shall not be illuminated until 2 conditions are met:

1. Emergency phase shall be green.
2. Phase selector shall have registered a pre-emption call.

Emitter equipment shall not be provided for this emergency vehicle pre-emption system.

B. Optical Detector.

1. The optical detector shall be a lightweight, weatherproof device capable of sensing and transforming pulsed optical energy into electrical signals usable by the phase selection equipment.
2. The unit shall be high-impact polycarbonate construction with non corrosive hardware.
3. The unit shall be designed for simple mounting at or near an intersection on mast arm, pedestal, pipe, or span wire.
4. The unit shall accept optical signals from two directions and provide a single electrical output signal.
5. The unit shall include a design feature to allow aiming of the two optical sensing inputs for skewed approaches or slight curves.
6. The unit shall have a built-in terminal strip to simplify wiring connections.
7. The unit shall receive power from the phase selector and be operational from 16 to 40 unregulated DC volts.
8. The unit shall be responsive to the optical emitter at a distance of 1800 feet.
9. The unit shall be capable of providing the necessary electrical signal to the phase selector through up to 1,000 feet of optical detector cable.

10. The unit shall employ a replaceable circuit board assembly and photocells to facilitate repair.

C. Optical Detector Cable.

1. Optical system cable shall be tested and certified by the manufacturer of the priority system components that the cable meets or exceeds matched component system performance.
2. The cable must guarantee delivery of the necessary quality signal from the optical detector to the phase selector over a non-spliced distance of 1,000 feet.
3. The cable must guarantee sufficient power to the optical detector over a non-spliced distance of 1,000 feet.
4. The cable must be of durable construction to satisfy the following installation methods:
 - a. Direct burial
 - b. Conduit and mast arm pull
 - c. Exposed overhead (supported by messenger wire)
5. The weight must not exceed .04 lbs./ft.
6. The outside diameter shall not exceed 0.3 inches.
7. The insulation rating must be 600 volts minimum.
8. The temperature rating must be 80°C. minimum.
9. The cable shall have 3 conductors of AWG20 (7 x 28) stranded, individually tinned, copper color coded as follows:
 - a. Orange for deliver of optical detector power (+)
 - b. Blue for optical detector power return (–)
 - c. Yellow for optical detector signal
10. The conductors will be shielded with aluminized polyester and have an AWG20 (7 x 28) stranded and individually tinned drain wire to provide signal integrity and transient protection.
11. The shield wrapping shall have a 20% overlap to ensure shield integrity following conduit and mast arm pulls.

D. Phase Selection Equipment.

1. The priority control system manufacturer shall offer devices to assure interface with electromechanical controllers, solid-state controllers with or with-

out internal priority control capability, and Type 170 controllers with internal priority control software.

2. Phase selector for use with internal preempt controllers.
 - a. Shall be a plug-in, two channel, dual priority device intended to be installed directly into the input file of internal preempt controller equipped with priority phase selection software.
 - b. Shall be powered from AC mains and contain an internal, regulated power supply to power optical detectors.
 - c. Shall be capable of recognizing the following pulse rates as delivered by the optical detectors:
 - (1) $9.639 \pm .119\text{Hz}$ as Frequency I
 - (2) $14.035 \pm .255\text{Hz}$ as Frequency II
 - d. Primary optical detector inputs and power outputs shall be on the card edge. Two additional detector inputs, per channel, shall be provided via a front panel connector.
 - e. An opto-isolated output shall provide the following signals to the card edge:
 - (1) $6.25 \pm .02\text{Hz}$ pulse in response to a low frequency signal
 - (2) A “Steady-On” in response to a high frequency signal
 - f. Shall utilize crystal controlled timing and optical pulse rate recognition circuitry to assure:
 - (1) Accurate optical signal (dual frequencies)
 - (2) Synchronous logic
 - (3) Precise output pulse
 - (4) Accurate call drop-out time
 - g. Shall have six recessed range controls per channel, three per frequency, to independently adjust optical sensitivity.
 - h. Shall have a solid-state “Power-On” indicator.
 - i. Shall have a “Frequency I” and Frequency II” solid-state indicator for each channel which performs as follows:
 - (1) Flashing during call validation
 - (2) Be steady-on when processing a valid call and during test switch operation

- j. 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.
- k. Shall have a selectable call dropout time of 5 seconds (10 seconds optional) -0 to $+2.5\%$.
- l. Shall properly identify a Frequency II demand with any combination of up to 10 high and low priority emitter signals being received simultaneously and asynchronously on either channel.
- m. Shall not exceed the following dimensions:
 - (1) Length (including handle) 7.91 inches.
 - (2) Width 1.11 inches.
 - (3) Height 4.50 inches.

E. **Reliability.** 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 in the NEMA TS 2 Traffic Controller Assemblies with NTCIP Requirements.

F. **Responsibilities.**

- 1. The manufacturer or the manufacturer's representative shall provide quality service before, during, and after installation of the priority control system. The manufacturer or the manufacturer's representative, as consultants to the installer, must provide certified trained technicians having traffic systems industry experience and operational knowledge of priority control systems.
- 2. Before bid/quote activity, the manufacturer or its authorized representative shall conduct field surveys of intersection control equipment to determine the most appropriate phase selection device for each location and to recommend locations for installing optical detectors.
- 3. After an award, the manufacturer or its authorized representative shall be responsible for system documentation including the following:
 - a. Acquire all relevant controller information.
 - b. Determine the number of vehicle phases (greens).
 - c. Determine the desired greens for priority approaches.
 - d. Determine ring configuration of each controller.
 - e. Establish pedestrian phase timing requirements.
 - f. Establish minimum green times for non-priority phases.
 - g. Establish the manipulation method of each controller type.

- h. Supply interface information to installer.
 - i. Assist in system checkout prior to purchaser's acceptance by:
 - (1) Verifying proper installation per recommended interfaces
 - (2) Verifying that optical ranges are properly set
 - (3) Verifying that phase selector timings or controller software timings* are properly set
- *System checkout requirements when using the plug-in version of phase selector must include verification that when two plug-in units are used, the controller must recognize high frequency over low frequency and first-come, first-served. All possible conditions of priority control must be considered. This may require software and/or hardware changes in the traffic controller. Software and programming of these controllers is the responsibility of the purchasing/using agency.
- j. Instruct emergency vehicle operators or their representatives in the operation of the system. Instruction shall include introductory training, periodic training updates, and a leave-behind audio visual self instruction course for on-going training.
 - k. Instruct maintenance personnel in routine maintenance of the system.
 - l. Manufacturer's technical support shall include technical service, design engineering, manufacturing engineering, and research engineering for system development, process management of priority control components, and for in-depth training of system users.

896.18 SPAN WIRE.

The span wire shall be a double galvanized 7 strand steel wire cable not less than 3/8-inch in diameter meeting ASTM A-475.

896.19 STABILIZATION WIRE.

The stabilization wire shall be a double galvanized 7 strand steel wire cable not less than 1/8-inch in diameter meeting ASTM A-475.

896.21 SERVICE POLE.

The Class II wood service pole shall be treated according to Section 846.

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