

700 MATERIAL DETAILS

Materials shall conform to the stated requirements and/or the requirements of the referenced specifications including modifications as noted.

Copies of all Supplemental Specifications referenced in this section are on file with the City of Columbus Transportation Division.

713 - FREEWAY LIGHTING AND ELECTRICAL MATERIALS

Specific materials and miscellaneous shall be as identified in the City's Street Lighting Specifications which are covered in the 1000 section of these specifications and supplementals to these specifications for Street Lighting on local city streets.

713.00 General. Freeway Lighting and electrical materials covered by these specification shall be inspected and certified as follows:

1. **Inspection.** Lighting and electrical materials are subject to inspection at the project site. Such inspection will include but is not limited to identification of the item, type, size and manufacturer's markings, and documentation of these data. When required by the City, random samples will be selected from the material delivered or at the place of manufacturing or prior to delivery.
2. **Certification.** When required by the City, certified test data shall be furnished.

In the case of light poles and light towers, certified test data in triplicate covering the specified requirements for all materials incorporated in the poles, towers and accessories and the results obtained from the deflection test shall be furnished to the City.

713.01 Light Poles.

1. **Scope.** These specifications cover materials and manufacturing methods to be used in the fabrication of light poles used to support luminaires at heights of less than 70 feet (21.3 m) above the foundation. Any aluminum or steel material permitted by the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" may be used in this item. Pole designs shall conform to minimum requirements of the AASHTO specifications cited, except that the design wind load shall, in all cases, be based on a wind speed of 90 miles per hour (145 km/h).
2. **Shafts.**

- (a) There shall be not more than one longitudinal, automatically electrically welded seam and no transverse seams or welds, except as permitted hereinafter. The longitudinal welded seam shall be neat and uniform in appearance, the weld shall not be less than the thickness of the base material, and the bead height shall not exceed 1/16 inch (1.6 mm). The wall shall be of uniform thickness throughout, except at the weld bead. The cross-section of the shaft shall be circular, or multisided with no less than eight sides, and the diameters or cross sectional dimensions, measured at any point along the longitudinal axis, shall not vary from each other more than 3/16 inch (5 mm). Poles may consist of not more than two vertical shafts jointed by overlapping the sections at least 1 1/2 diameters of the bottom of top section, and by use of a 5/8 inch (16 mm) minimum stainless steel hex head through bolt. The minimum length for the shorter section of a 2-piece shaft shall be 10 feet (3.0 m) with the shortest section being the top section.
- (b) Shafts for steel poles shall be tapered tubes with a true continuous taper.
- (c) Shafts for aluminum poles shall be tapered tubes either spun or cold rolled. The shaft shall have a true continuous taper, except for the top and bottom sections which may be straight. No more than 40 percent of the total shaft length shall be straight.
- (d) The average rate of shaft taper, including straight portions of the shaft shall be between 0.06 and 0.16 inch per foot (5.0 and 13/3 mm/m).
- (e) The deflection of the unloaded shaft from the vertical position when placed under load by attachment of the bracket arm, luminaire weighting 75 pounds (34 kg) and lamp shall not exceed an angle of 1 degree and 10 minutes (1.17 degrees) when tested in accordance with ODOTCMS Supplement 1025.
- (f) On poles equipped with tubular sleeve supports for bracket arms, the sleeve shall pass through a hole in the shaft and be made an integral part of the shaft by means of circumferential welds where sleeve and shaft join. The sleeve shall extend from the shaft sufficiently to insure stability of the connection.
- (g) Fittings shall be as detailed on the plans and the approved shop drawings. Fasteners, washers, shims, nuts, and bolts, unless otherwise specified, shall be either stainless steel conforming to ASTM A 320/A 320M (AISI-300 series), galvanized steel

conforming to 711.02 or silicon bronze conforming to ASTM B 98 M(B98). Nonstructural castings for aluminum poles, including the shaft cap and transformer base door, shall be ASTM B 26/B 26M or B 108, Alloy S 5 A, Condition F.

3. **Anchor Type Bases.**

- (a) Anchor bases for steel poles shall be one-piece cast steel conforming to 711.07 or steel plate conforming to 711.01. The anchor bases shall be welded to the pole shaft both inside and outside with fillet welds equal to the wall thickness, or by AWS prequalified welding joints TC U4a-S or TC U4c-GF.
- (b) Anchor base for aluminum poles shall be one-piece cast aluminum conforming to ASTM B 26/B 26 M or B 108, Alloy 356.0, Temper T6. The anchor bases shall be secured to the lower end of the shaft and the base shall telescope over the shaft. When a welded connection is used, 2 continuous welds shall be required with one weld at the lower end of the shaft and the other weld at the top of the base. The two welds shall be at least 1 1/2 inches (38 mm) apart. The base connection shall develop the full design strength of the adjacent shaft section in bending.

4. **Transformer Type Bases.** Transformer type bases shall be fabricated from steel or aluminum in accordance with the following:

- (a) Steel transformer base designated on the plans by Styles ST-A, ST-B, ST-C, and ST-X shall meet the dimensional requirements of plans and approved shop drawings. They shall be made from steel conforming to ASTM A36/A 36M. Doors shall be fabricated so that they will fit flush with the face of the base and shall be permanently attached by means of a top-mounted continuous stainless steel hinge. Bases for poles mounted on median barrier shall be one-pass welded, unless otherwise noted.

Style	Bolt Circle Diameter inches (mm)	Base Height inches (mm)
ST-A	15 (381)	20 (508)
ST-B	22 (559)	24 (610)
ST-C	17 1/4 (438)	20 (508)
ST-X	10 1/2-13 (267-330)	20 (508)

- (b) Aluminum transformer bases designated on the plans by Styles AT-A, AT-C, and AT-X shall meet the dimensional requirements of the plans and approved shop drawings. A base shall be capable

of transmitting the design dead, live, ice and wind loads of the light pole to be mounted on it to the foundation without failure or permanent deformation. They shall also comply with the fragility requirements specified in the AASHTO "Standard Specifications for Structural Support for Highway Signs, Luminaires and Traffic Signals."

The aluminum transformer bases shall be permanently marked for exterior identification. Doors shall be fabricated so that they will fit flush with the face of the base, and shall be permanently attached by means of a top-mounted, continuous, stainless steel hinge. The door shall be latched by means of a tamperproof, quarter-turn latch.

Style	Bolt Circle Diameter inches (mm)	Base Height inches (mm)
AT-A	15 (381)	17 (432)
AT-C	17 1/4 (438)	17 (432)
AT-X	10 1/2-13 (267-330)	17 (432)

- (c) The transformer base shall be fastened to the shaft anchor base by means of four heavy hex head bolts and nuts conforming to ASTM A 307 and galvanized in accordance with 711.02. When aluminum transformer bases are used with non-galvanized steel anchor base poles, both the bottom of the steel anchor base and the top of the aluminum transformer base shall be coated or painted with a heavy film of zinc rich paint.
5. **Steel Anchor Bolts and Nuts.** Anchor bolts shall be steel with 55,000 psi (380 MPa) (minimum) yield strength. The threaded ends of the bolts and nuts shall be galvanized in accordance with 711.02. Galvanizing shall extend at least 2 inches (50 mm) beyond the threads. Anchor bolts shall be provided with nuts capable of developing the full strength of the anchor bolt.
6. **Bracket Arms.**
- (a) Bracket plates and other fittings shall be dimensioned and detailed as shown on the plans, the standard drawings, and the approved shop drawings. The arms shall be made of not less than 2 inch (50 mm) nominal pipe size material and have (1) the longitudinal axis of the luminaire end canted not less than 1 degree nor more than 4 degrees above the horizontal, (2) an internal raceway of 1 3/32 inches (28 mm) minimum I.D. free of projections and obstructions, which, when assembled to the shaft, will permit installation of

luminaire supply conductors without insulation damage and with a minimum radius bend of conductors of 3 inches (76 mm) and (3) a 2 inch (50 mm) nominal pipe size slipfitter end with a minimum length of 8 inches (203 mm) to receive a slipfitter-mounted luminaire. The bracket arm members may be formed of straight or tapered stock, but shall be of a round or ovaliptic cross-section. Except for poles equipped with tubular sleeve supports, the bracket arm assembly for arms 8 feet (2.4 m) or longer shall consist of an upper and lower member securely joined by means of a vertical strut or struts.

- (b) Steel bracket arms supported on a circular, tapered stud, integral with the pole shaft, shall be made from a one or two-piece round tapered sleeve. The bracket arm shall be securely held within the sleeve by means of a 5/8 inch (16 mm) machine bolt extending diametrically through both bracket arm and sleeve. A hex head nut and lock type washer shall be used to secure the bolt.
- (c) The shaft end of each aluminum bracket shall have a cast, wrought, or extruded aluminum fitting welded to it for attaching to the shaft.

7. **Welding.**

- (a) Steel shall be welded as required by 513.17.
- (b) Fabrication and welding of aluminum piles and bracket arms shall conform to the requirements of AWS D1.2 Structural Welding Code-Aluminum.

8. **Finishing.** Steel poles, except stainless, shall be hot dipped galvanized after fabrication in accordance with the requirements of 711.02.

Aluminum poles shall be furnished in matching natural aluminum color. Pole shafts shall be furnished with a polished or satin brushed surface. Shaft and bracket arm assembly shall be wrapped with a heavy water-resistant paper or be otherwise suitably protected during shipment and installation. The wrapping shall not be removed until after complete installation.

9. **Tests.** The Director may require the approval of poles to be based on complete testing, including destructive testing at the factory prior to delivery. Tests shall be supervised by a representative of the City and shall be performed on poles selected at random from a lot produced for the City. Approval of subsequently produced poles will generally be based on Departmental evaluation of mill tests and factory certified test results on the materials and fabricated components.

713.02 Electrical Cables.

1. **Scope.** This item shall consist of insulated conductor cables to be used for four classes of service; namely, 300 volt, 600 volt, 5,000 volt and 15,000 volt. All cable shall meet requirements of IPCEA S-66-524. Coding to identify a neutral conductor is acceptable.
2. Cable to be used for 300 volt, 600 volt, or 5,000 volt (secondary class) service shall be of the sizes specified, nonjacketed, single conductor, stranded copper having an unshielded chemically cross-linked polyethylene insulation and shall meet the following requirements.

Cable shall meet the requirement of UL Type RHH-RHW-USE. However, UL Type XHHW may be used for cable sizes No. 10 AWG and smaller.

3. 5,000 volt cable to be used for 600 volt (secondary class) service shall be of the sizes specified, single conductor, stranded copper having an unshielded, chemically cross-linked polyethylene insulation, and shall meet the requirements of UL Type MV-90 dry.
4. Cable to be used for 5,000 volt and 15,000 volt (primary class) service shall be of the sizes specified, stranded copper or aluminum, and, as shown on the plans, shall be either of the following types:
 - (a) Primary Underground Residential Distribution Cable with concentric neutral and complying with IPCEA S-66-524 Part 7.1.
 - (b) Separate primary and neutral standard shielded cables. The separate neutral conductor shall have the same characteristics, composition and conductivity as its companion power conductor, except for possible color coding.

713.03 Unit Type Duct-Cable Systems.

1. **Scope.**

This item shall consist of a factory preassembled cable in a coilable, high density polyethylene pipe type duct providing the number and size of insulated conductors which are specified. The number of conductors used in the duct and the duct fill shall conform to the requirement of the National Electrical Code, but in no case shall the inside diameter of the duct be less than 1 1/2 inches (38 mm).

2. **Conductors and Neutrals.** The cables used as conductors and neutrals shall conform to 713.02.
3. **Polyethylene Duct.** Duct shall conform to NEMA TC-7. The manufacturer's name and the year of manufacture shall be included in the marking. Compound shall be high density polyethylene, Type III, Class C, Category 5, Grade 34.

713.04 Rigid Ferrous Metal Electrical Conduit and Fittings. Galvanized steel conduit and fittings furnished under this specification shall comply with the requirements of ANSI C 80.1 and UL 6 for Type I. Each length of conduit shall bear the UL label. Fittings furnished under this specification shall comply with the requirements of ANSI/NEMA FBI and ANSI/UL 514B.

713.07 Polyvinyl Chloride Conduit and Fittings. This specification covers polyvinyl chloride conduit, Type DB for direct burial without concrete encasement, and the Type EB for encased burial in concrete. Polyvinyl chloride conduit and fittings, of the size and type specified, shall conform with NEMA Standards Publication No. TC-2 or TC-6.

713.08 Concrete Pull Box.

1. **Pull Box.** Concrete pull boxes shall be constructed and installed as detailed in the plans.
2. **Covers.** Pull box covers shall be constructed and installed as detailed in the plans, and shall have the word "ELECTRIC," "TRAFFIC," or "TELEPHONE," formed on the surface or displayed on an attached metal plate in accordance with 713.09.

713.081 Plastic Pull Box. Plastic pull boxes and covers shall be high density ultraviolet stabilized polyethylene or polycarbonate, or fiber reinforced resin or foamed moldings, adequately reinforced and with a box wall thickness of at least 1/4 inch (6 mm). Openings may be round or square; or oval or rectangular if the ratio of major to minor axis does not exceed 2.0. Box depth may be achieved by extensions or stacking. Covers shall be slip resistant and shall bear the work "ELECTRIC," "TRAFFIC," or the initial letter of the word. Covers shall fit tightly and be secured by stainless steel hardware. Box size and strength shall conform to the following table:

Nominal inches (mm)	Clear Opening, square inches (m ²) (approximate)	Depth, inches (mm)	Test Load, pounds* (kN)
8 x 8 (203 x 203)	45 (0.03)	18 (457)	2500 (11)
10 x 14 (254 x 356)	120 (0.08)	24 (610)	2500 (11)
13 x 18 (330 x 457)	210 (0.14)	24 (610)	4500 (20)

16 x 25 (406 x 635) 400 (0.26) 18 (457) 5000 (22)

* The pull box with any extensions shall support the test load distribution uniformly at the cover center over a 10 by 10 inch (254 by 254 mm) area, or 8 by 8 inch (203 by 203 mm) for the smallest box. Maximum deflection shall be no more than 1/2 inch (13 mm) at the cover center or 1/4 inch (6 mm) at the top edge. There shall be no breakage or permanent deformation.

713.09 Polymer Concrete Pull Box. Polymer concrete pull box and cover material shall consist of aggregate bound together with polyester resin and reinforced with continuous woven glass strands. The box shall carry the load designation ASTM C857. Covers shall be resistant and shall be slip resistant and shall bear the word "ELECTRIC" or "TRAFFIC". The cover and box shall be designed to be installed flush to grade with cover fitting flush to the box. The pull box lid shall be held securely in place with stainless steel inserts and bolts.

Normal Size In. (Mm)	Clear Opening (Approximate) Sq. In (M²)	Depth In. (Mm)	Design Load Lbs. (Kn)
13 x 24 (330 x 610)	132 (0.08)	18 (457)	8,000 (35)
17 x 30 (432 x 762)	512 (0.30)	18 (457)	8,000 (35)

The pull box shall support the test load of 1.7 times the design load distribution uniformly at the cover center area 10 by 10 inches (250 x 250 mm) without failure or damage.

713.10 Junction Boxes.

1. **Scope.** This specification covers junction boxes of the sizes and types shown on the plans.
2. **Composition.** Junction boxes shall be iron castings and shall be hot-dip galvanized in accordance with 711.02.
3. **Detailed Requirements.**
 - (a) Junction boxes shall be NEMA ICS-6-Type 4 of the size specified, and also meet UL50 requirements.
 - (b) D Conduit entrances shall be provided as shown on the plans.

713.11 Luminaries for High Intensity Discharge Lamps.

1. **Scope.** This specification covers pole-bracket-arm mounted luminaires for high intensity discharge lamps. The luminaire shall be a complete lighting device, consisting of a housing, lamp, support clamp, reflector,

refractor, socket, integral ballast or separate ballast when specified and terminal block. The luminaire shall be capable of operating the lamp in a completely sealed optical assembly at the line voltage specified. The luminaire shall provide the ANSI-IES Type distribution and cut-off specified.

The luminaire shall be supplied with a label or decal indicating the type of source and wattage rating. With the luminaire installed in its normal operating position, the label or decal shall be clearly legible in daylight at a distance of 50 feet (15.2 m). Labeling shall be in accordance with the provisions of NEMA publication No. OD-150 or EEI Publication No. TDJ-150.

The use of the small, medium, or large size luminaire shall be determined by the initial lamp lumen rating of the specified lamp type as follows:

- (a) The small horizontal Style A luminaire shall not be used for lamps rated over 16,000 lumens.
- (b) The medium horizontal Style B luminaire shall not be used for lamps rated over 37,000 lumens.
- (c) The large horizontal Style C luminaire shall not be used for lamps rated over 55,000 lumens.

2. **Detail Requirements.**

- (a) **Housing.** The housing shall be of cast aluminum with natural finish or a painted finish, using aluminum or a light gray color paint. The housing shall contain and support the reflector, refractor, socket, ballast, terminal block and support clamp. Provision shall be made for leveling to adjust the luminaire to the specified transverse and longitudinal position with respect to the roadway.

The luminaire shall be equipped with a device indicating the direction and amount of tilt over a range of 0 to 5 degrees in any direction. The level indicator shall have three major calibrations which are accurate within 1/2 degree. The calibrations shall be approximately as follows:

- (1) Level
- (2) Three-degree tilt
- (3) Five-degree tilt

The indicating device shall be clearly discernible in daylight from a distance of 50 feet (15.2 m) and shall in no way alter or reduce the amount of light from the luminaire. It shall be constructed of a transparent contained having one horizontal surface which is curvilinear in any vertical cross-section for supporting an indicator and a damping fluid. The damping fluid shall be a liquid which shall be suitable for operation at -40° F (-40° C). The transparent container shall be fabricated from clear ultraviolet-inhabited acrylic or similar material.

- (b) **Refractor Retaining Ring.** The refractor retaining ring shall be securely latched and hinged with non-corrodible material and shall be operable and removable without the use of tools. The assembly shall provide a weatherproof enclosure for the optical system.
- (c) **Support Clamp.** The support clamp shall be the slip-fitter type adaptable to 1 1/4 or 2 inch (32 or 51 mm) mounting bracket. A stop shall be provided to allow an engagement of at least 4 1/2 adjust and hold the luminaire in its specified vertical and horizontal position.
- (d) **Reflector.** The reflector shall be of an approved specular polished aluminum reflective surface. It shall be held firmly in the housing, but shall be easily removed without the use of special tools. Silicon rubber, ethylene propylene terpolymer, or dacron felt gaskets or approved equal shall seal the optical assembly at the socket entry and between the refractor and reflector to make a dust tight optical system. The reflector shall be clean and free from scratches.
- (e) **Refractor-Glass.** The refractor shall be heat resistant borosilicate glass and shall have prisms on the inside and on the outside to provide the ANSI-IES type distribution and cutoff as specified and shall be free of striations and imperfections. The refractor shall be embossed to clearly indicate the street side and curb side prisms. The refractor shall be securely fastened to the holder, but easily removed. The refractor, reflector assembly shall meet the specified ANSI-IES distribution and cutoff. The Contractor shall provide complete photometric data for every combination of each assembly.
- (f) **Socket.** The socket shall be a mogul screw shell with large center contact spring providing a firm contact with the lamp base. The socket shell shall have lamp grips to prevent the lamp from loosening. The shell may be of the skeleton type or shrouded in

porcelain. The contacts shall be identifiable. Socket extension adaptors will be permitted for special applications. Luminaires providing various ANSI-IES types of distribution by socket adjustment shall also include a means of identification to associate each lamp position with each distribution type. The socket adjustment shall provide positive positioning by means of index holes, lugs or notches. Slots with infinite settings will not be acceptable.

- (g) **Ballast.** Ballasts shall conform to the following requirements.
- (1) The mercury ballast shall be a high power factor, constant wattage type and shall be rated to the circuit voltage and size of lamp specified. The ballast shall start the lamp at temperatures as low as -20° F (-29° C) and shall deliver rated lamp current at circuit voltage variation of plus or minus 10 percent. The regulation output of lamp wattage shall not exceed a total range of plus or minus 5 percent.
 - (2) The metal halide ballast shall be a high power factor, peak load autoregulator type rated to the circuit voltage and size of lamp specified. The ballast shall start the lamp at temperatures as low as -20° F (-29° C) and shall deliver rated lamp watts within plus or minus 10 percent with plus or minus 10 percent variation in applied voltage.
 - (3) The high pressure sodium ballasts for lamps through 400 watts shall be a high power factor, regulator type with isolated primary and secondary windings and shall be rated to the circuit voltage and size of lamp specified. Ballasts for 1000-watt high pressure sodium lamps shall be a high power factor, autoregulator type rated to the circuit voltage specified. The ballast shall start the lamp at temperatures as low as -20° F (-29°C) and shall deliver rated lamp current at circuit voltage variations of plus or minus 10 percent. All ballasts shall be complete with starter components.

The starter component shall be comprised of solid state devices capable of withstanding ambient temperatures of 220° F (100° C). The starter shall provide timed pulsing with sufficient follow through current to completely ionize and start all lamps that meet published ANSI standards. The starter component shall be field replaceable and completely interchangeable with no adjustment necessary for proper operation. It shall have push-on type electrical

terminations to provide good electrical and mechanical integrity and ease of replacement. The starter circuit board shall be treated in an approved manner to provide a water and contaminant resistant coating.

The starting circuit-ballast combination shall be designed to consistently provide the following parameters:

- (a) Lamp wattage must be maintained within the trapezoid recommended by lamp manufacturers within the full rated input voltage range.
- (b) Amplitude of the pulse shall be 2,500 volts minimum and 4,000 volts maximum. Operation of the pulse at spike voltage levels near minimum is desirable.
- (c) The minimum pulse width shall be 1 microsecond at 2,250 volts, and shall be applied within 20 electrical degrees of the peak of the open circuit voltage wave, and have a minimum repetition rate of one pulse per cycle of the 60 cycle wave.
- (d) Pulses must be present when ballast is correctly wired and nominal voltage less 15 percent is applied to the ballast windings.
- (e) The high pressure sodium ballast, including starting aids, shall protect itself against normal lamp failure modes. The ballast shall be capable of operation with the lamp in an open or short circuit condition for six months without significant loss of ballast life.

The luminaire manufacturer shall supply ballast electrical data and lamp operating volt-watt traces for nominal and plus or minus ten percent rated line voltage to verify ballast performance and compliance with ANSI lamp specifications, for the rated life of the lamp.

- (4) The low pressure sodium ballast shall be a high power factor corrected (90 percent minimum) reactor type rated to the circuit voltage and size of lamp specified. The ballast shall start the lamp at temperatures as low as -20° F (-29°C) and shall deliver rated lamp current at circuit voltage

variations of plus or minus 10 percent. Wattage regulation shall not exceed a range of -5 percent to +3 percent for lamps rated at 90 watts or more.

- (h) **Glare Shields.** Glare shields of aluminum or opaque plastic material shall be provided when specified. The shield shall be supplied by the manufacturer of the luminaire. The glare shield shall cut off the upward component of light, but shall not reduce the total output of the luminaire more than 3 percent.

713.13 Luminaires for Underpasses.

- 1. **Scope.** This specification covers luminaires for mounting in underpasses. The luminaire shall be a complete lighting device, consisting of a housing, reflector, lamp, shrouded porcelain socket, refractor, door, integral ballast conforming to the requirements of 713.11, and fuse holder with fuse. The assembly shall be prewired, and shall be weatherproof and sealed against dust.
- 2. **Detail Requirements.** (a) The high pressure sodium fixture shall consist of a cast aluminum housing and door frame assembly containing a thermal shock resistant glass refractor attached to the frame with stainless steel latch and hinges. The glass refractor shall be protected by an approved guard or shield. (b) The low pressure sodium fixture shall consist of a cast aluminum rear mounting plate with a one-piece luminaire housing and refractor molded of a polycarbonate material with integral prismatic design for proper beam control. The one-piece housing shall be hinged and secured to the rear mounting plate.

713.14 Lamps.

- 1. **Scope.** This specification covers mercury, metal halide, high pressure sodium, low pressure sodium, incandescent and fluorescent lamps for use in luminaires. The lamps shall be the type and wattage specified. Each lamp shall be provided with a date recording feature.
- 2. **Mercury Lamps.**
 - (a) Mercury lamps for use in the luminaire specified shall be first line, high quality lamps having heat resistant clear glass envelopes with a quartz arc tube interior. The horizontal initial lumens and approximate hours of life shall not be less than those values shown in the following table:

ANSI	Watts	Horizontal Initial Lumens	Economic Life Hours
------	-------	------------------------------	------------------------

H38HT	100	3,900	16,000
H39KB	175	6,950	16,000
H37KB	250	10,500	16,000
H33CD	400	19,200	16,000
H35NA	700	34,600	16,000
H36GV	1,000	53,000	16,000

- (b) The lumen output of the mercury lamps after 12,000 hours use shall produce a minimum of 78 percent of its initial lumen rating.

3. **High Pressure Sodium Lamps.**

- (a) High pressure sodium lamps for use in the luminaire specified shall be first line, high quality lamps having heat resistant clear glass envelopes with a ceramic arc tube interior. The horizontal initial lumens and approximate hours of life shall not be less than the values shown in the following table:

ANSI	Watts	Horizontal Initial Lumens	Economic Life Hours
S62	70	5,800	14,000
S54	100	9,500	14,000
S56	150	16,000	16,000
S66	200	22,000	16,000
S50	250	25,500	16,000
S67	310	37,000	16,000
S51	400	50,000	16,000
S52	1,000	130,000	16,000

- (b) The lumen output at the end of economic life shall be not less than 80 percent of the initial lumen rating.

4. **Metal Halide Lamps.**

- (a) Metal halide lamps for use in the luminaire specified shall be first line, high quality lamps having heat resistant clear glass envelopes with a quartz arc tube interior. The horizontal initial lumens and approximate hours of life shall not be less than those values shown in the following table.

ANSI	WATTS	Horizontal Initial Lumens	Economic Life Hours
------	-------	------------------------------	------------------------

M57	175	14,000	4,000
M58	250	18,000	4,000
M59	400	32,000	10,000
M47	1,000	95,000	7,500

(b) The lumen output at the end of economic life shall be not less than 65 percent of the initial lumen rating.

5. **Low Pressure Sodium Lamps.** Low pressure sodium lamps for use in the luminaire specified shall be first line, high quality lamps, with a sodium resistant discharge tube contained in a clear glass envelope. The initial lumens and approximate hours of life shall be not less than those values shown in the following table:

Watts	Initial Lumens	Economic Life Hours
35	4,000	16,000
55	8,000	16,000
90	13,500	16,000
135	22,500	16,000
180	33,000	16,000

6. **Incandescent Lamps.** Incandescent lamps of the size, type and wattage specified shall conform to Federal Specification Number W-L-101.
7. **Fluorescent Lamps.** Fluorescent lamps of the size, type and wattage specified shall conform to Federal Specification Number W-L-116.

713.15 Cable Connecting Devices.

1. **Scope.** This specification covers cable connecting devices, including connectors, connector kits, cable splicing kits, and in-the-line type fuseholder kits. All devices shall be rated for minimum 600 volt service.
2. **Cable Connectors.** Cable connectors shall be the types which are applied to the conductor by means of a compression tool and they shall be capable of fully enclosing the conductors upon which they are compressed in accordance with the manufacturer's instructions. Connectors shall be fabricated from high strength copper alloy. Plated connectors fabricated from metals other than copper will not be accepted.

Style "C" cable connectors shall be the splicing sleeve type which shall consist of a crimpable plated copper sleeve with a thin metal wall or "stop" in the barrel centered between each sleeve end so the sleeve shall

enclose equal lengths of the two conductors being spliced end-to-end. The barrel of the sleeve is manufactured to fit specific ranges of conductor sizes. The manufacturer's instructions relating thereto shall be strictly followed.

3. **Cable Connector Kits.** Each cable connector kit shall be furnished complete with all component parts described under the various listed types and each kit shall have the following:

- (a) Sufficient silicon compound to lubricate metal parts and the housing for each assembly.
- (b) Complete installation instructions.

The component parts of each type of kit shall comply with the following:

- (c) **Housing.** All housings shall be made of water-resistant synthetic rubber suitable for burial in the ground or exposure to sunlight. Each housing shall form a water-seal around the cable, between each other housing at the point of disconnection and between an insert body and enveloping "Y" housing.
- (d) Copper pins, sockets and fuse contacts shall have a minimum conductivity of 90 percent. They shall be of at least half hard material and the crimpable portion shall be fully annealed while the rest of the device is maintained in its original state of hardness.
- (e) Contact pressure between a pin and a socket shall be maintained by the use of an approved socket spring.
- (f) Where a mounting hole is provided for fastening terminal lugs to a ring-tongue terminal, they shall be fastened with a bolt and self-locking nut.
- (g) Plastic sleeves shall be rigid, molded insulating plastic material of sufficient outside diameter to form a water-tight fit with it related housing. Wall thickness shall be 0.10 inch (2.5 mm) maximum and sleeve lengths shall be as required.
- (h) All fuses shall be rated 600 volts, 100,000 amperes RMS interrupting capacity.

Each cable connector kit furnished under this specification shall conform to one of the following types:

Type II. Fused, Quick Disconnect Y Connector Kit. Each Type II kit shall contain: (a) A pair of spring loaded copper fuse contacts suitable for gripping the specified cartridge fuse. One contact shall be crimpable on a conductor and after insertion into its proper position within the load-side plug housing to be capable of being securely retained therein. The other contact shall be preassembled for retention within a Y insert body. (b) A line-side Y housing with two cable ports. (c) Two terminal lugs, each having a mounting hole. (d) A bolt and self-locking nut. (e) A Y insert body with preassembled line side fuse contact and a ring tongue terminal. (f) A load-side plug housing permanently marked "load-side." (g) A fuse of specified ampere rating.

Type III. Unfused, Quick Disconnect Y Connector Kit. Each Type III kit shall contain: (a) A copper pin crimpable to a conductor and suitable for retention in the load-side receptacle housing. (b) A Y insert body with preassembled load-side copper socket and ring-tongue terminal (c) A line-side Y housing with two cable ports. (d) Two terminal lugs, each having a mounting hole. (e) a bolt and self-locking nut. (f) A load-side receptacle housing.

Type IV. Semi-permanent Y Cable Connector Kit. Each Type IV kit shall contain: (a) A ring-tongue terminal crimpable to a conductor. (b) Two terminal lugs, each having a mounting hole. (c) A bolt and self-locking nut. (d) A line-side Y housing with two cable ports. (e) A load-side insert body with one cable port.

Type V. Unfused In-line Connector Kit for Junction Box Installation. Each Type V kit shall contain: (a) A copper pin crimpable to a conductor and suitable for retention in the receptacle housing. (b) A copper socket crimpable to a conductor and suitable for retention in the plug housing. (c) A receptacle housing. (d) A plug housing.

Type VI. Fused In-Line Connector Kit for Junction Box Installation. Each Type VI kit shall contain: (a) A pair of spring loaded copper fuse contacts, both crimpable to conductors and suitable for gripping the specified cartridge fuse. Both contacts shall be capable of being securely retained in their housings. (b) A plug housing. (c) A receptacle housing.

Type VII. Splice Insulating Kit. Type VII kits shall be classified as follows: (a) Type VII A kit consisting of: two identical housings, each having single cable port, one plastic sleeve, one Style "C" cable connector. (b) Type VII B kit consisting of: one housing having a single cable port, one housing having a twin cable port, one plastic sleeve, two style "C" cable connectors. (c) Type VII C kit consisting of: two identical housings, each having a twin cable port, one plastic sleeve, three Style "C" cable connectors.

4. **In-the-Line Type Fuseholder Kits.** Each in-the-line type fuseholder kit shall be provided with a breakaway receptacle to physically interrupt the circuit under impact. The breakaway unit shall be mounted on the line side and consist of a wire connector for the external circuit and an insulating sleeve housing a deeply recessed female terminal. The

assembly shall be completed by a conventional in-the-line fuseholder with its line terminal being a solid copper rod. When assembled, the male terminal of the fuseholder shall telescope into the insulating sleeve of the receptacle and make a sliding contact with the female receptacle terminal. There shall be four similar styles of breakaway receptacles differing only in the type of connector for the line side conductors as follows;

- (a) **Type VIII** - AL Kits shall provide an in-the-line mounting for the fuseholder. It shall contain a setscrew-type connector for aluminum conductor.
- (b) **Type VIII** - CU Kits shall provide an in-the-line mounting for the fuseholder. It shall contain a crimp type terminal that will accept a single copper conductor.
- (c) **Type IX** - AL Kits shall provide a tee tap to the fuseholder. The setscrew connector shall be made of aluminum to accept aluminum conductors.
- (d) **Type IX** - CU Kits shall provide a tee tap to the fuseholder. The setscrew connector shall be made of copper to accept copper conductors.

Insulating boots of water-resistant, synthetic rubber, suitable for burial in the ground or exposure to sunlight, shall be provided for both the line and load side of all fuseholder kits with breakaway receptacles.

- 5. **Cable Splicing Kits.** Each cable splicing kit shall contain all items necessary to complete a permanent, direct buried, water resistant, inline, wye or tap splice as required by the plans. Cable splicing kits shall be either a transparent rigid mold, resin-filled type, or a heat-shrinkable sleeve, or a wraparound pad coated with a heat-activated self-encapsulating adhesive. Each kit shall include the following:
 - (a) A sleeve or tee cable connector conforming with the general requirements of Style "C" or other connecting device approved by the Engineer.
 - (b) A means of containing the sealing material around the cable connector.
 - (c) Sufficient self-hardening compound to assure a watertight splice.
 - (d) Heat shrinkable tubing or pre-molded boots for sealing ends of duct-cable.

- (e) Complete installation instructions.

713.16 Ground Rods and Ground Grid.

1. **Scope.** This specification shall cover ground rods and ground grids.
2. **Detail Requirements.** Ground rods shall have either a circular cross-section with a diameter of 1 inch (25 mm) or more or, if other than circular in cross-section, they shall have a periphery of 3.2 inches (81 mm) or more. Rods shall be 10 feet (3.0 m) long, solid, and shall have a driving point on one end. Rods for ground grid shall be 3/8 inch (10 mm) minimum diameter (approximately 30 feet (9.1 m) in length) solid rods with blunt ends. Rod material shall be stainless steel jacketed steel bearing UL label or hot-dip galvanized steel in accordance with ASTM A 153, Class B-1.

In lieu of solid metal rods, ground grids composed of 3/8 inch (10 mm) diameter preformed 7-strand, utilities grade, Class B, messenger wire conforming to ASTM A 475 may be used.

713.17 Structure Ground Cable.

1. **Scope.** This specification shall cover the cable to be used for electrical grounding of structures.
2. **Requirements.** Cable shall be stranded, soft-drawn, insulated, copper of the size shown, bearing a UL label or conforming to paragraph No. 2 of Section 713.02.

713.18 Circuit and Light Pole Identification Materials.

1. **Scope.** This specification covers the materials to be used as identifying markings on cables and light poles as follows:
2. Tags to be used as specified shall be circular in shape, 1 3/8 (35 mm) minimum diameter, 1/32 inch (0.79 mm) minimum thickness copper, brass or plastic, except that tags within switch and device cabinets shall be of nonmetallic material. Identifying bands shall be approximately 1/32 inch (0.79 mm) thick, 3/16 inch (0.5 mm) wide and 4 inch (102 mm) minimum length nylon, self-clinching type with adequate sized tab for labeling. Tags shall be permanently fastened to cables by means of tying straps of the same material and dimensions as identifying bands without tabs. Each tag or band tab shall be marked using 1/4 inch (6 mm) minimum lettering dies or by the use of embossing or engraving devices. Markings shall indicate "GRD" for all ground and grounded neutral conductors.

Companion circuit conductor shall be marked "CKT" followed by the designated letter, numeral or symbol as may be shown on the plans.

3. Pole identification shall be accomplished by means of adhesive labels with silver white reflective characters on a reflective green background meeting the requirements of 730.18.

713.19 Power Service Components.

1. **Scope.** These specifications cover materials and equipment normally comprising a service pole and including service equipment as follows:
2. **Poles and Pole Keys.** Poles and pole keys shall be Southern Yellow Pine or Western Red Cedar, full length, pressure treated in compliance with specifications of the American Wood Preservers Association, using copper naphthenate. Retention of preservation in Southern Yellow Pine shall be 0.60 pounds (1.0 kg) of copper by lime-ignition assay per cubic foot (cubic meter) of wood. Retention of preservative in Western Red Cedar shall be 0.12 pound (2 kg) of copper by lime-ignition assay per cubic foot (cubic meter) of wood. Poles shall be 35 feet (10.7 m) minimum length and Class 4 or heavier, conforming to the applicable requirements specified by ANSI Pole Dimensions. Poles shall be reasonably straight without pronounced sweep or short crooks.
3. **Wood Crossarms.** Wood crossarms shall be treated and of the specified dimensions. Treatment shall be as specified in No. 2 above.
4. **Pole Hardware.** Pole hardware, including bolts, nuts, washers, clamps, screws, braces, racks, etc., shall be of specified sizes, galvanized in accordance with 711.02.
5. **Ground Wire Supports.** Ground wire fastened to the pole shall be attached with copper clad, rolled point staples of adequate size to accommodate the ground wire to be supported.
6. **Ground Wire Molding.** Ground wire molding shall be either wood or plastic, in sections not less than 8 feet (2.4 m) long and of sufficient width and groove depth to completely enclose the ground wire. Molding shall be attached to pole by means of galvanized steel pipe straps and galvanized nails.
7. **Anchors and Anchor Rods.** Anchors shall be malleable iron, 6 inch (152 mm) minimum diameter, two-way or four-way expanding type. Anchor rods shall be 5/8 inch (16 mm) minimum diameter, 8 feet (2.4 m) minimum length galvanized steel provided with twin thimbleye.

8. **Guy Strand.** Guy strand shall be 3/8 inch (10 mm) minimum diameter, conforming to ASTM A 475, galvanized steel.
9. **Primary Service Equipment.**
 - A. Transformers shall be pole mounted distribution type, oil-filled, single or double primary bushing, with taps of 2 1/2 percent above and below the specified voltage, furnished with hanger bracket or equipment for cross arm mounting and having the specified ratings of KVA capacity, primary and secondary voltages. Transformers may be self-protected with internal primary fuse and secondary breaker or conventional type.
 - B. Primary fused disconnects and lightning arresters shall be open type, having the specified ratings for voltage, amperage, interrupting capacity instantaneous amperes RMS.
 - C. Primary switches shall be open blade type, single-pole, single-throw; remote controlled oil immersed type or ground operated air break type.
 - D. Cable pothead terminations shall have the specified ratings for phase-to-phase operating voltage, impulse voltage at 1 1/2 x 40 wave, corona voltage level to ground, cable range and corona voltage acceptance level.
10. **Secondary Service Equipment.** Riser conduit shall be as specified in 713.04 with a rain-tight galvanized steel service entrance head (weatherhead) threaded to fit the specified size of conduit and provided with a composition cover for 2 or 3 wire service.

The service disconnecting device shall be a fused safety switch or circuit breaker rated 600 volts AC minimum for 480 volt service or 240 volts AC minimum for 240 volts or less service. Current rating of the device shall be as specified, but not less than 60 amperes. Circuit breaker shall be service equipment type. Devices shall be single throw with the specified number of poles and solid neutral not interruptible with operation of the device, but other means for disconnecting the grounded neutral shall be provided at the neutral terminal block. Fuse clips for cartridge type fuses shall be provided at the load side terminals of the switch. If the disconnecting device is a circuit breaker type and separate load side protection is required for two circuits, this shall be accomplished by the use of one single-pole, single throw circuit breaker type device of the specified ampere rating mounted in services with the main breaker.

Line and loadside cable terminal lugs of the device should be sized to accommodate the specified wire sizes. If lugs of adequate size to enclose the total outside diameter of the cables cannot be furnished, insulated buses of specified ampere rating and dimensions and providing acceptable cable terminations shall be furnished and installed as directed by the Engineer.

11. Lighting circuit transformers shall be dry type without taps, having the specified KVA rating to step up the supply voltage of 120/240 volts to 480 volts, single-phase, 60 Hz.
12. Contractor circuit transformers shall be dry type having the specified wattage rating to step down the lighting circuit voltage of 480 volts to 120 volts, single-phase, 60 Hz. A fuse shall be provided in series with the 480 volt winding.
13. Lighting Contractor shall be open type rated 600 volts AC and provided with an electromagnetically held 120-volt, 60 Hz coil. The Contractor shall be rated at 60 amperes minimum and shall have a minimum of three poles. A "HAND-OFF-AUTO" selector switch shall be provided in the photoelectric cell circuit and located within the enclosure.
14. Photoelectric control shall be a utility grade, solid state, cadmium sulfide type with hermetically sealed silicon rectifier rated 121 or 480 volts, 60 Hz and 1000 watts maximum load. Built-in surge protection shall be provided and a fail-safe operating feature shall be included so that the lighting circuits will remain energized in the event the photo control components become inoperative. Nominal operating levels of this control shall be "turn on" at a minimum illumination value of 1 vertical footcandle (11 lx) and "turn-off" at a maximum illumination value of 6 vertical footcandles (65 lx). These limitations shall be set by the manufacturer and maximum tolerances of ± 20 percent for the specified values will be acceptable.

Photoelectric controller shall be a twist-lock type. A suitable mounting bracket with EMI-NEMA locking-type receptacle and all other necessary mounting hardware shall be furnished.

15. Lightning arrester shall be secondary type, having the specified number of poles and rated 0-650 volts rms. Arrester shall be provided with suitable mounting brackets and all other necessary mounting hardware.
16. Enclosures shall be NEMA ICS-1-110.15 Type 4 and shall be adequate to house the designated equipment for outdoor locations. Enclosure shall be fabricated from No. 16 gage or heavier AISI Type 302 or 303 annealed stainless steel with a brush finish. All seams shall be fully welded. All

fastenings used in assembly or mounting of the enclosures shall conform to ASTM A 320/A 320M (AISI-300 series).

Each enclosure shall be provided with a door so constructed that it may not be opened when the principal electrical disconnecting device mounted therein is in the "ON" position. However, provision shall be made by means of a lockable double-defeater opening handle to permit intentional opening of the door with a screwdriver when the disconnecting device is in the "ON" position.

Each enclosure shall be provided with the following:

- (a) A door provided with a mechanism interlocking the door latch and the operating handle, including provision for padlocking. The mechanism shall be defeatable in the following sequence when the operating handle of the disconnecting device is in the "ON" position. (1) Release door latch with one hand on door latch handle while simultaneously operating door latch defeater screw with a screwdriver in the other hand. (2) Open door with one hand on door latch handle while simultaneously operating disconnect handle defeater screw with a screwdriver in the other hand.

The door latch defeater screw shall be sufficiently recessed within its housing so as not to be turned with a coin or flat washer.

The door latching mechanism shall provide that the door handle must be turned to fully engage its latch before the disconnect handle can be moved to the "ON" position.

- (b) An insulated solid copper common neutral bus of adequate ampere rating and capable of terminating the specified sizes of wire.
- (c) A schematic wiring decal of the entire control center installed on the inside of the door.
- (d) An equipment warning sign reading "DANGER-HIGH VOLTAGE" stenciled on the outside of the door in red weather-resistant paint or the same wording etched on a brass plate riveted to the outside of the door. See 625.19 for other markings.
- (e) A 14 gauge or heavier enameled steel panel, securely fastened to the inside of the back of the enclosure and of adequate size to accommodate all devices and integral wiring on all sides and to the rear.
- (f) Mounting flanges, hubs, weep holes, etc., as shown on the plan.

713.21 Light Towers.

1. **Scope.** These specifications cover materials and manufacturing methods to be used in the fabrication of light towers, tower components, and anchors used to support luminaires at heights of 70 feet (21.3 m), and greater, above the foundation. The design of light towers shall comply with applicable AASHTO requirements as set forth in the "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals," with the design wind load based on a wind speed of 90 miles per hour (145 km/h), with a maximum load of six luminaires, each weighing 75 pounds (34 kg) with a projected area of 3.5 square feet (0.3 m²), mounted on a head frame assembly with top latched lowering device having a projected area of 5.3 square feet (0.5 m²) and weighing 340 pounds (154 kg).
2. **General.** The integral luminaire lowering device shall be compatible with the tower design and consist of a head frame assembly, a luminaire ring assembly, and winch assembly. The system shall permit luminaire maintenance at ground level, provide a permanently attached plug and cord for energizing the lighting assembly when it is at ground level, support two to six 75 pound (34 kg) luminaires in a symmetrical arrangement, and include power cables and all miscellaneous electrical and mechanical equipment in the tower necessary to provide a complete and workable device. Outlets, inlets and plugs for connecting electrical power to the luminaire mounting assembly shall have pin arrangements conforming to NEMA Configurations for Locking Devices as follows: for 3-wire, 240 volt systems, use NEMA Configuration G-33, and for 2 wire, 480 volt systems, use NEMA Configuration G-17. Disconnection of the electrical service at each tower shall be accomplished by means of a two-pole, 30 ampere, 480 volt breaker with a minimum symmetrical RMS interrupting capacity of 14,000 amperes, complete with NEMA 4 enclosure with grounded neutral bar. The breaker shall be internally mounted and readily accessible through the tower handhole.

A complete service manual, including instructions on installation, operation, and maintenance shall be furnished for each lowering device, winch assembly, and power drive system furnished on the project.

3. **Shafts.** Tower shafts shall consist of not more than four round or multisided tapered steel sections for shafts up to and including 100 feet (30 m) in length, five sections between 101 and 120 feet (31 and 37 m), and six sections over 120 feet (37 m). Steel used in fabricating the shaft shall have a minimum yield strength of 55,000 psi (379 MPa) after fabrication or meet the requirements of an approved alternate design. Shop drawing submissions of alternate proposed designs shall be

accompanied by sufficient calculations to demonstrate to the satisfaction of the Engineer that the design proposed meets the minimum requirements of the AASHTO specifications cited.

Sections shall either telescope with each other or be shop butt welded by electric arc welding. The lap joint produced by telescoping shall have a length that is the larger of two feet (0.6 m) or 1 1/2 diameters of the shaft at the joint, measured at the minimum diameter of the inner telescoping section. The sections shall be prefitted and match-marked at the factory. The inside surface of the shaft shall be relatively smooth to provide a cable raceway.

There shall be no more than two longitudinal welds in the tapered sections of the shaft which shall be made by automatic electric arc welding. Transverse butt welds may be used, but only under closely-controlled shop conditions. All shaft welds, except on longitudinal seams, shall have complete penetration, shall have uniform density, and shall be no thinner than the shaft material nor more than 20 percent thicker than the shaft material. Shaft welds on longitudinal seams shall have at least 60 percent penetration, except in areas where the shaft section telescopes over another section. In the overlapping areas, longitudinal seam welds shall be complete-penetration welds for a distance of the nominal splice length, plus six inches (152 mm).

The shaft shall be joined to the base plate using the American Welding Society prequalified joint TC-U4a-S or TC-U4c-GF. All handholes or openings in the shaft shall be properly reinforced to avoid stress risers and be welded to the shaft using a joint and techniques designed to insure total penetration, plus an outside fillet equal to the thickness of the shaft material. The handhole shall be gasketed to make it weatherproof. The door shall be fabricated from the same type steel as the shaft and attached with continuous stainless steel hinges having nonremovable stainless steel hinges having nonremovable stainless steel hinge pins. The door shall include provisions for padlocking. Each tower shall be furnished with at least one padlock. The padlock shall have a bronze or brass lock body and a corrosion-protected steel shackle. All padlocks for a project shall be keyed alike and the Contractor shall obtain the master key number from the maintaining agency. A tapped hole shall be provided at the base of the tower for a 1/2 13 (13 mm) galvanized bolt and washer connection for the grounding cable to be carried through the electrical metallic tubing in the foundation to the ground rod.

Shafts shall be hot dipped galvanized after fabrication in accordance with the requirements of 711.02.

4. **Luminaire Ring Assembly.** The luminaire ring assembly shall be fabricated from steel which conforms to ASTM A 36/A 36M or material which has the same strength characteristics as the tower. The ring shall be fitted with the appropriate number of 2 inch (50 mm) nominal steel pipe mounting arms. The luminaire ring shall be prewired with copper conductor of adequate size and insulation to facilitate wiring the required number of luminaires. All power cables shall be terminated in a NEMA 4 corrosion resistant junction box with weathertight cable connections. The main electrical supply cable and its cable clamp terminator shall support one and one-half times the full cable weight without cutting the conductors or insulation and without stretching the outer jacket of the cable. The similar connection of the electrical cable to the cable termination within the tower shall meet the same requirements, but shall be capable of supporting the weight of the cable, plus a wind load on the cable length due to 30 miles per hour (48 km/h) winds. The junction box shall include a secondary line lightning arrestor and 600 volt terminal block, completely prewired. A weather tight twist lock power inlet shall be provided on the luminaire ring to allow testing of the luminaire ring while in the lowered position.

The luminaire ring shall be supported by three galvanized or stainless steel aircraft cables of 7 strands, 19 wires each, with a minimum diameter of 3/16 inch (5 mm). Each of the three cables shall be secured to the ring and to the cable terminating device within the tower by means of compatible corrosion resistant devices. The connection of the three cables to the terminator shall be shop applied, swage-type fittings designed to develop a holding strength equal to the breaking strength of the cable.

Positive latching devices shall be incorporated into the ring assembly. These devices shall be designed to prevent any movement of the ring assembly when it is latched to the top of the pole and tension is removed from the ring support cables. All moving parts of the latching devices shall be a part of the luminaire ring assembly. Reflectors or flags shall be provided to indicate when the luminaire ring assembly is completely and securely latched to the head assembly. The indicating flags or reflectors shall be clearly discernible from the ground when the luminaire ring is in the latched position. To prevent unnecessary stress on luminaires and lamps, the latching sequence shall not exert a horizontal force sufficient to cause an excess of 4 g's acceleration upon the luminaires.

The ring assembly shall have a minimum of three roller-contact spring located centering arms in continuous contact with the pole shaft during raising and lowering of the ring. The guide arm rollers shall be made of a nonabrasive, water-resistant material.

5. **Head Frame Assembly.** The head frame assembly shall be fabricated from steel which conforms to the requirements of ASTM A 36/A 36M, or steel which has the same strength characteristics as the tower. It shall consist of all necessary pulleys and rollers to guide the hoisting cables and electrical cable. The minimum tread diameter for the hoisting cable sheaves shall be 20 times the cable diameter for galvanized cable and 25 times the cable diameter for stainless steel cable. The hoisting cable sheave groove cross-section shall be semi-circular with a radius of one-half the cable diameter, plus 1/64 inch (0.4 mm). All hoisting cable sheaves shall be suspended on stainless steel shafts fitted with oil-impregnated bronze bushings.

The power cord roller assembly shall consist of rollers mounted between two cold-rolled steel plates. The power cord shall ride on rollers mounted on AISI 304 stainless steel shafts. Rollers shall be located on a radius on either end of the plates to support the power cord in a minimum 7 inch (178 mm) bending radius. At either end of the plates, a keeper bar shall be provided over the power cord between the plates to keep the cord in its track during pole erection and during normal operating.

A guide shall be provided to separate the individual cables so that twisted or tangled cables cannot reach a pulley.

The headframe assembly shall be protected from the weather by a dome cover made of either copperfree spun aluminum or fiberglass.

6. **Winch Assembly.** The winch drum shall have a diameter not less than 4 inches (102 mm), and shall be supported by rigidly mounted bearings of the proper load capacity. The drum flanges shall have a diameter at least 3 inches (76 mm) greater than the drum. A set of guides or a cable follower shall be provided to prevent cable buildup at the ends of the winch drum. Keepers shall be provided to prevent cable from fouling after the tension has been relieved.

The winch shall be driven by a worm gear reducer equipped with a self-locking device. The gear reducer shall be permanently lubricated and shall be enclosed in a housing of cast aluminum, cast iron, or other approved material. The gear reducer shall have an ultimate output torque capacity five times greater than that required to lift the nominal load.

7. **Winch Drive System.** The winch assembly shall be externally powered by a heavy duty reversing drill motor, or NEMA frame motor, minimum 3/4 horsepower (559 W) rating, 120 volt. A torque limiter of size and rating recommended by the manufacturer shall be incorporated into the system to prevent overloading the hoisting system. The system shall include a transformer to step down the existing system voltage to 120

volts. The hoisting rate shall be between 15 and 25 feet per minute (4.6 and 7.6 m/min.). A remote hand control unit with not less than 20 feet (6.1 m) of cord shall be provided to allow operation of the unit while positioned away from the pole.

8. **Base Plates.** The base plate shall be fabricated from steel which conforms to the requirements of ASTM A 36/A 36M.
9. **Anchor Bolts and Nuts.** Anchor bolts shall be steel with 85,000 psi (379 MPa) (minimum) yield strength and shall be galvanized in accordance with 711.02. Galvanizing shall extend at least 2 inches (51 mm) beyond the threads. In lieu of a bent end, a drilled and tapped steel plate of approved size and thickness may be used. Anchor bolts shall be provided with nuts capable of developing the full strength of the anchor bolt.
10. **Fittings.** 713.01, 2 (g), except that galvanized steel fittings shall not be permitted.
11. **Welding.** 513.17. All welds in the shaft shall be tested by ultrasonic or approved alternate method, and certification of this requirement shall be furnished to the Laboratory. Acceptance level shall satisfy AWS D.1 Structural Welding Code Article 9.25.3 for tensile stress.
12. **Luminaires.** The luminaires shall consist of an optical assembly, lamp, ballast, and aluminum housing with side entry mounting for a 2 inch (51 mm) pipe, which shall provide adjustment for leveling. The mounting attachments shall prevent twisting of the luminaire about the bracket. The entire unit shall be of substantial design adequate to operate at 70 to 150 foot (21.3 to 46 m) mounting heights when subjected to wind velocities of 90 miles per hour (145 km/h). When specified for use with 1,000 watt lamps, the unit shall be provided with a lamp support around the neck of the lamp and independent of the socket.

The lamp socket shall be a heavy duty mogul, multiple prewired, porcelain enclosed type, with integral lamp grip, and large center contact spring providing a firm contact with the lamp base. The socket assembly shall be present to provide the ANSI-IES distribution specified in the plans, but shall have provisions for adjustment to provide vertical control of the angle of maximum light intensity. The actual projected area of the ballasted luminaire shall not exceed 3.5 square feet (0.3 m²). The ballast shall comply with the applicable sections of 713.11 and be rated to the circuit voltage, type and size of lamp specified in the plans.

The maximum beam intensity for the Type V distribution shall not exceed 325 candela per 1,000 lamp lumens at angles between 55 and 65 degrees from nadir (downward). The nadir initial intensity shall not exceed 100 candela per 1,000 lamp lumens. The Type V optical design shall be capable of producing a uniformity of

illumination with a maximum to minimum ratio not greater than 6.0 to 1, and an average to minimum ratio not greater than 3.0 to 1, with luminaires mounted in a square array spaced at 4.0 times the mounting height.

The maximum beam intensity for the Type II and III asymmetric distributions shall not exceed 425 candela per 1,000 lamp lumens at angles between 66 degrees and 73 degrees from nadir. The nadir initial intensity shall not exceed 175 candela per 1,000 lamp lumens. The system illumination results obtained from the asymmetric optical design shall be capable of producing a uniformity of illumination with a maximum to minimum ratio not greater than 6.0 to 1, and an average to minimum ratio not greater than 3.0 to 1, with luminaires spaced at 5.0 times the mounting height and located along one side of an area whose width is 1.5 times the mounting height.

The maximum beam intensity for the Type I asymmetric distribution shall not exceed 425 candela per 1000 lamp lumens at angles between 66 degrees and 73 degrees from nadir. The nadir initial intensity shall not exceed 175 candela per 1000 lamp lumens. The system illumination results obtained from the asymmetric optical design shall be capable of producing a uniformity with a maximum to minimum ratio not greater than 6.0 to 1, and an average to minimum ratio not greater than 3.0 to 1, with luminaires spaced at 5.0 times the mounting height and located along the centerline of an area whose width is 0.75 times the mounting height on either side of the centerline.

The output efficiency of all high mast luminaires shall be not less than 65 percent of the bare lamp lumens, with 25 to 35 percent of the bare lamp lumens contained in the 60 to 90 degree vertical zone.

The design of the high mast luminaires shall be such that the entire arc tube of the lamp shall be optically shielded at angles above 70 degrees from nadir.