

**985.1 REQUIREMENTS****A. Electrical Grounding and Bonding:**

- 1. Grounding Wire:** Grounding wire from electrical cabinets to the ground rod shall be bare, soft drawn copper, size per NEC. Grounding wire from pole to ground rod shall be bare, soft drawn copper, minimum size No. 6 AWG.
- 2. Bonding Conductors:** Bonding conductors shall be of the same size and insulation grade as the associated circuit conductors. Load size bonding jumpers shall not be smaller than the applicable size listed by the NEC, Table 250-95.
- 3. Ground Rods:** Ground rods shall be copper-coated electrodes in accordance with Underwriters Laboratory (UL). The size and length shall conform to NEC requirements.

**B. Electrical Conduit:**

- 1. Rigid Steel Conduit:** Conduit and fittings shall meet the requirements of UL 6 and 514 and shall be hot dip galvanized. Each section of conduit shall bear the UL label.
- 2. Rigid Nonmetallic Conduit:** Conduit and fittings shall be polyvinyl chloride heavy wall meeting the requirements of UL 651 and 514. Use and installation of PVC Schedule 40 and 80 shall be in accordance with NEC Article 347 and each section shall bear the UL label. When nonmetallic conduit is to be used in areas subject to vehicular traffic, it shall be Schedule 80.

**C. Junction Boxes:** Shall meet the following requirements:

1. Corrugated metal pipe shall conform to the requirements of AASHTO M 36.
2. Surface mounted boxes shall be a noncorrosive metal box with a NEMA rain tight lid designed for mounting on any surface to which a conduit can be attached. The box shall be a manufactured electrical box suitable for accepting conduit junctions, electrical wire splices, and for use as a pulling facility for electrical wire.
3. Lid and cover assemblies for corrugated metal junction boxes shall be cast iron Neenah Foundry Co. R5900 Series, Deeter Foundry, Inc. 1973, 1977, 1981 Series or equal. The word, ELECTRIC or ELECTRICAL and the word SIGNAL or LIGHTING, as appropriate, shall be cast into the top of the cover.

- D. Concrete Footings:** Concrete for footings shall meet the requirements for Class M6 (I28) concrete. Cement shall be Type II. Vertical reinforcement shall be grade 40 or 60 (300 or 400) and shall conform to the requirements of ASTM A 615M. Circular ties, stirrups, and spiral reinforcing may be fabricated from cold drawn wire ASTM A 82 or hot rolled plain or deformed bars conforming to the strength requirements of ASTM A 615 grade 40 or 60 (300 or 400).

**E. Anchor Bolts:** Anchor bolts shall conform to Section 972.

**F. Electrical Power Cable:** Electrical cables shall be type THW, THWN or XHHW rated for 600 volts AC and be clearly and durably marked with the UL label, type of insulation, number of conductors, and the AWG size.

Traffic signals and traffic signals with intersection lighting using the same service cabinet shall utilize stranded copper meeting the requirements of ASTM B3 and B8, Class C. Roadway lighting shall utilize stranded copper conductors for service, feeder, and branch circuits.

**1. Underground Cable (Direct Burial):**

- a. Cables shall be made up of single or multiple conductors and shall meet the applicable requirements of ICEA Standard Publications S-19-81, S-61-402, S-66-524, or applicable UL standards.
- b. When underground armored cable is specified, multiple conductor cable shall be provided with bronze tape armor meeting the requirements of ASTM B130, with a minimum thickness of 10 mils (0.25 mm) and a spiral overlap of not less than ¼ inch (6 mm).
- c. The multiconductor cable shall be either cross linked or butyl insulated.

**2. Pole and Bracket Cable:**

- a. The cable from pole base to luminaire shall be two-conductor of the AWG size shown, meeting ICEA Standards.
- b. Conductors shall be THWN/THNN meeting ASTM B3. Conductors shall be stranded bare soft copper meeting ASTM B3 and B8, Class C. Each conductor shall be insulated with high dielectric strength heat and moisture resistant polyvinyl chloride rated for use at 75° C, and shall meet the requirements of ICEA S-61-402 Section 7.1.3. One insulated conductor shall be colored white and the other black. The two insulated conductors shall be laid parallel and covered with a black polyethylene belt. The belt shall meet the requirements of ICEA S-61-402 Section 7.1.5.

**G. Traffic Signal Control Cable:**

1. **Multiple Conductor Cable:** Shall be THHN/THWN insulated conductors with fillers of nonabsorbent material, bound with polyester tape and with a polyvinyl chloride jacket. Two-conductor cables may either round or flat construction.
2. **Conductors:** Shall be Class C stranded copper meeting the requirements of ASTM B3 and B8.
3. **Insulation:** Insulation shall have a minimum thickness of 19 mils (0.48 mm) of which 15 mils (0.38 mm) shall be polyvinyl chloride with the remaining thickness of nylon.

4. **Colors:** Conductor insulation shall be colored in accordance with ICEA S-61-402, Method 1, Table K-2.
5. **Jackets:** Jackets shall be polyvinyl chloride meeting UL requirements for Class 12 jackets and ICEA S-61-402 Section 4.3.1, thickness per table 4.5.
6. **Markings:** The cable shall be marked with the name of the manufacturer, rated voltage, UL label, AWG size, and number of conductors.

#### **H. Electrical Service Cabinet:**

1. Shall meet NEMA standard for rain tight.
2. Shall be equipped with a lock and two keys.
3. Size shall be as required to house required components.
4. Shall be rated for service entrance equipment.
5. Required components:
  - a. Main breaker.
  - b. A copper bus rated for the voltage, current, and phases required by the plans.
  - c. Branch circuit breakers meeting plan requirements for amps, voltage, and phases. Minimum A.I.C. shall be 10,000.
  - d. When fused disconnects are required, the disconnects shall be rated for the voltage and current shown on the plans and shall be UL rated.
  - e. When plans require, a mechanically held contactor, NEMA rated for the load served, shall be provided. The contactor shall be encased in a UL approved weatherproof housing with an integral test switch included. The contactor shall be complete with an interface relay for photocell control and photocell bypass switch. A photocell shall be provided.

#### **I. Traffic Signal Poles:**

1. **Design:**
  - a. The location, number, area, and weight of the signal heads as shown on the plan detail plates shall be used for determination of adequate pole and footing structural design. The actual quantity and locations of signal heads shall be as shown on the plan sheet.
  - b. Design and fabrication shall be in accordance with "AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals", current edition, interim specification and plan details. Cantilever traffic signal supports,

including anchor bolts, shall be designed for fatigue in accordance with Fatigue Importance Category I.

- c. Wind pressure shall be calculated as per Equation 3-1 based on a basic wind speed of 90 mph (145 kilometers per hour).
  - d. The design yield strength shall be no higher than 55,000 psi (380 MPa). Strength of steel for fabricating poles may be higher than 55,000 psi (380 MPa), but not lower than 36,000 psi (248 MPa).
  - e. Either transformer base or hand hole type poles may be provided, but all poles on a contract must be of the same type.
  - f. Anchor bolt circle, anchor bolt size, and other structural properties of the pole and base are to be designed and determined by the pole manufacturer.
  - g. A terminal block with enough connections to accommodate all conductors, including spares, as shown on the field wiring diagram, shall be provided in the base of the pole.
  - h. Pole designs must provide for drainage with no laps or edges to hold moisture.
  - i. Mast arm pole shafts shall have a removable cover and an opening for cable entrance to the mast arm.
  - j. A "J" hook for a cable strain relief grip shall be provided at the point of entrance to the mast arm or electrical fixture.
  - k. Luminaire extensions shall meet specifications for Roadway lighting poles.
  - l. Hand holes and other openings shall be smooth and neat. For grounding purposes, a ½ inch (M12) nut shall be welded inside the hand hole. The weld shall not show through to the outside.
2. **Certification:** A statement is required, signed by a Registered Professional Engineer, certifying that the pole designs meet all plan and specification requirements.
  3. **Shop Plans:** The fabricator shall initially submit seven (7) copies of the shop plans and/or catalog cuts for traffic signal poles, signal equipment to the Office of Road Design for review. Comprehensive design calculations for the traffic signal poles (including anchor bolts), signed and sealed by a SD Registered Engineer shall be submitted with the shop plans. One reviewed copy of the shop plans will be sent to the fabricator who will then make the necessary changes, if any, and then send the Office of Road Design seven (7) final approved copies for distribution. A copy of the transmittal letter shall be furnished to the Project Engineer.

Attn: Traffic Design Engineer  
Office of Road Design  
700 E Broadway Ave.

Pierre, SD 57501-2586

Phone: (605) 773-3433

FAX: (605) 773-6608

## J. Roadway Lighting Poles:

### 1. Design:

- a. Design and fabrication shall be in accordance with "AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals", current edition, interim specifications and plan details. Tower lighting, including anchor bolts, shall be designed for fatigue in accordance with Fatigue Importance Category I.
- b. Wind pressure shall be calculated as per Equation 3-1 based on a basic wind speed of 90 mph (145 kilometer per hour).
- c. The design yield strength for steel shall be no higher than 55,000 psi (380 MPa). Yield strength of the steel used in fabricating poles may be higher than 55,000 psi (380 MPa) but shall not be lower than 36,000 psi (248 MPa).
- d. Either transformer base or hand hole type poles may be provided, but all poles on a contract must be of the same type.
- e. Anchor bolt circle, anchor bolt size, and other structural properties of the pole and base are to be designed and determined by the pole manufacturer.
- f. Pole designs must provide for drainage with no laps or edges to hold moisture.
- g. Mast arm pole shafts shall have a removable cover and an opening for cable entrance to the mast arm.
- h. A "J" hook for a cable strain relief grip shall be provided at the point of entrance to the mastarm or electrical fixture.
- i. Hand holes and other openings shall be smooth and neat. For grounding purposes, a ½ inch (M12) nut shall be welded inside the hand hole. The weld shall not show through to the outside.

2. **Certification:** A statement is required, signed by a Registered Professional Engineer, certifying that the pole designs meet all plan and specification requirements.

3. **Shop Plans:** The fabricator shall initially submit seven (7) copies of the shop plans and/or catalog cuts for roadway lighting poles to the Office of Road Design for review. Comprehensive design calculations for the roadway lighting poles (including anchor bolts), signed and sealed by a SD Registered Engineer shall be submitted with the shop plans. One

reviewed copy of the shop plans will be sent to the fabricator who will then make the necessary changes, if any, and then send the Office of Road Design seven (7) final approved copies for distribution.

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#### **K. Luminaires:**

1. Must be a complete lighting device, weatherproof, with cast aluminum housing, reflector, refractor, lamp, lamp socket, terminal block, integral ballast, and with internal parts readily accessible.
2. Mounting must be by a two-inch (50 mm) slipfitter (except for wall mounts).
3. Refractor shall be constructed of clear, heat and shock resistant glass, or a material which gives similar light transmission with superior shock resistance.
4. Ballast shall be constant wattage and multiple voltage.
5. Wall mount luminaires must be vandal resistant.

#### **L. Photoelectric Control Requirements:**

1. The photoelectric cell shall meet EEI/NEMA OD3 and ANSI C136-10 standards and subsequent revisions.
2. The housing shall be nonmetallic and weatherproof and the cover must be ultraviolet light stabilized and impact resistant.
3. The load switch shall be an electromagnetic relay.
4. Mounting shall be to an EEI/NEMA three-terminal, polarized, twist lock type receptacle.
5. Shall operate on any electrical power between 105 and 285 volts, 50 to 60 hertz (AC).
6. Shall be equipped with an expulsion type arrester for surge protection and spark over.
7. Shall have a minimum of 3 second time delay to eliminate false operation due to lightning or stray passing lights.
8. Shall provide for fail safe operation. The light shall remain "ON" if the control fails.

9. Factory set to turn on at 1.0 footcandles (10 lux) and off at 3.0 footcandles (30 lux).

### **M. Controller Cabinet:**

#### **1. Cabinet Design:**

- a. The cabinet shall be made of welded sheet aluminum, welded steel, or cast aluminum alloy. Steel controller cabinets and mounting attachments are to be furnished completely painted with one coat of primer paint and two coats of high grade, highway yellow enamel, or galvanized.
- b. The type and size of cabinets shall be determined by the signal controller supplier. The cabinet shall be of sufficient size to accommodate the controller and associated equipment.
- c. The cabinet shall be furnished with a hinged door that provides complete access to the cabinet interior. The door shall be gasketed making a weatherproof and dust tight seal. The door shall be provided with a lock and standard keys. Base mounted cabinets shall be furnished with doorstops to hold the door open during servicing.
- d. The cabinet door shall contain a police panel with a lock and key. The police panel shall contain two switches. One switch shall be designated "flash/normal" and the other switch designated "signal off/on". At any switch position, power shall be maintained for all control equipment, including detector amplifier units, within the cabinet. The switch shall be labeled and rated for the current load. Switch terminals on the rear of the police panel shall be insulated so live parts are not exposed.

2. **Fan Assembly:** Cabinets shall be provided with thermostatically controlled fan vent assemblies. The thermostat shall be adjustable within a range from 75° F to 150° F (24° C to 65° C) and shall be separately fused. A screened and filtered air intake area of at least 12 square inch (75 square centimeters) shall be provided. The filters shall be removable, cleanable, reusable, and replaceable.

#### **3. Electrical:**

- a. A three wire 15 ampere NEMA standard double plug receptacle with ground contact and an Edison Base Lamp receptacle with an on/off switch shall be wired as a separate fused circuit ahead of the main breaker.
- b. A main circuit breaker shall be furnished and installed in the controller cabinet. An auxiliary circuit breaker shall be provided and connected to the load side of the main breaker. The main breaker shall be wired to protect the signal load and controller circuits. The auxiliary circuit breaker shall be properly rated and fused to protect circuits utilizing unfiltered AC power. Terminal facilities in the cabinet for incoming AC power will be protected to prevent short-circuiting when working with tools in the cabinet. The circuit breakers shall be capable of manual operation with markings to indicate ratings and whether it is in the open or closed position.

- c. A power line filter meeting the following specifications shall be installed at the main breaker:
  - 1) 50 db minimum attenuation over a frequency range of 200 kilohertz to 75 kilohertz.
  - 2) Hermetically sealed in a metal case.
  - 3) Minimum feed through current of 30 amperes at 120 volts, 60 hertz.
  - 4) A minimum of a ¼ inch (6 mm) current path between input output terminals and the metal case.
  - 5) Power input and output connections are made to 10-24 brass studs.
  - 6) An insulation factor between the line circuit and the metal case (ground) of 100M to 200M ohms.
- d. Surge Protection for dissipating line transient voltages shall be furnished and installed using a metal oxide varistor rated at 20 joules with a 150 volt r.m.s. clipping voltage connected between each 120 volts AC input line and AC common at the main breaker.
- e. The 120 volts AC power feed at the entrance to the controller cabinet shall be protected against lightning by a rare gas arrester. The arrester shall be located in advance of both the surge protector and the main circuit breaker, be properly grounded, and conform to the following:
  - 1) Replaceable, self-restoring, rare gas cartridge with hermetically sealed metal electrodes.
  - 2) Induction discharge period in excess of five amperes r.m.s. for two minutes or 25 amperes r.m.s. for one second or 15 amperes r.m.s. for ten seconds, all followed by complete restoration to original characteristics.
  - 3) Discharge voltage minimum of 200 volts.
  - 4) Mounted on a standard AAR porcelain base equipped with a spark gap discharge feature.
- f. Bus bar terminals such as AC common (neutral), AC power, safety (chassis) ground and AC signal power shall be furnished and properly installed.
- g. Terminals and panel wiring for detector leads, interconnect, time switches, relays, load switch sockets, flash transfer relay sockets, and any other components required to provide the controller operation shall be installed.
- h. Terminals and components that make up the basic terminal facilities shall be permanently identified in accordance with the cabinet wiring diagram. Identification shall be

- permanently attached as close as possible to the terminal or component and shall not be affixed to any part which is easily removed.
- i. Each input or output terminated on a terminal block shall be identified on the front of the panel by a position number and functional terminology (e.g. 0/1 Red, 0/2 Hold, Channel 3 Red, etc.). The same identification shall be used consistently on the cabinet wiring diagram.
  - j. Each component shall be identified on the front of the panel by a symbol and function terminology consistent with the cabinet wiring diagram. Provisions shall be made that each load switch socket can be identified by the phase or overlap number by writing on the panel in an area established for this feature.
  - k. Panel wiring shall be neat and firm with panel mounted terminals for signal lamp circuit conductors, one for each signal circuit, and one or more terminals for the common conductor. The terminals shall be located a minimum of three inch (75 mm) from the bottom of the cabinet and arranged for adequate clearance between the terminals. The controller equipment and terminals shall be arranged within the cabinet so they will not upset the entrance, training, and connection of incoming conductors.
  - l. A flasher socket and a solid state flasher meeting current NEMA standards shall be provided in the controller cabinet.

#### N. Controller:

**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.

Hardware for future pedestrian signals shall be provided when shown.

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.

Each controller shall be furnished with a malfunction management unit (MMU) conforming to NEMA performance standards.

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 operations occurs during the No. 1 interval in the cycle. When the controller is in a flashing condition, the signal switching mechanism shall be inoperative.

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.

The Contractor shall provide a technician trained in the operation of the controller at the time of signal activation. The technician shall be available for at least two consecutive days.

**1. Pretimed Controller:**

- a. The controller furnished shall meet current NEMA TS2 standards for controllers.
- b. Transfer from one cycle 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.
- c. 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 a type compatible with traffic control function requirements. The manual switches shall have skip day capability and battery backup for continuous operation 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.
- d. The controller shall have, as a minimum, the following features:

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

**2. Actuated Controller:**

- a. The controller furnished shall meet current NEMA TS2 standards for controllers.

**O. Detector Unit:**

- 1. **Components and Workmanship:** Shall conform to the standards of NEMA.

**P. Detector Loops:**

- 1. **Lead-in (Home Run) Wires:** Feeder wires from loop leads to detector units shall be twisted shielded pairs, Belden Number 8719, or equal, #16 AWG minimum size. Splices are to be avoided in feeder wires.

**2. Sawed-in Loops:**

- a. Conductors shall conform to the following requirements:

Material:	Stranded Copper
Size:	WG (Minimum)
Insulation:	XHHW, THHN, RHH, or RHW
Encasement:	(6 mm) Polyethylene tubing

- b. Backer rod material shall be resilient, nonabsorbent material approximately 25 percent larger in diameter than the width of the sawed slot to be sealed.
- c. Loop Sealants: Shall be one of the products as listed on the Approved Products List.

**3. Preformed Loops:** Conductors shall conform to the following requirements:

Material:	Stranded Copper
Size:	#16 AWG (minimum)
Insulation:	600 Volt, XLP, bearing the U.L. designation for either type RHH and RHW or type XHHW

**Q. Vehicular and Pedestrian Traffic Signal Heads:**

1. Vehicular Signal Heads must meet requirements of the ITE Standard, "Vehicle Traffic Control Signal Heads."
2. Pedestrian Signal Heads must meet requirements of the ITE Standard, "Pedestrian Traffic Control Signal Indications."
3. Size: Shall be a minimum of 12 inches (300 mm) diameter.
4. Color: Doors, visors, and backplates shall be dull black and housing highway yellow.
5. Material may be either cast aluminum or polycarbonate resin.
6. Visors shall be of the "Tunnel" type.
7. Backplates for Signal Heads:

Material: Unless otherwise stated on the plans, backplates may be either 0.050 inch (1.27 mm) thick aluminum or 0.125 inch (3.18 mm) thick plastic. The plastic backplates must be made up from no more than two pieces.

**R. Pedestrian Button:** All pedestrian push buttons shall be a 2" ADA (Americans with Disabilities Act) pedestrian push button.

The switching device for the pedestrian push button shall be a reed switch sealed in the backside of the pedestrian push button and activated by a sealed magnet in the plunger. Mechanical parts for the pedestrian push button shall also be sealed to eliminate contact exposure to ambient air and weather. The switch and magnet shall be UL approved components.