

SECTION 1104—TRAFFIC SIGNALS

1104.01 GENERAL REQUIREMENTS—Comply with the requirements of associations, societies, codes, and regulations, as applicable.

Fabricate traffic signal structural material according to [Section 1105](#) (steel members only), AWS, and the AASHTO Specifications; except, applying water to the base metal during plasma arc cutting is permitted. [Bulletin 15](#) listing and shop inspection is required. Fabricators provide an AWS certified welding inspector (CWI) for welded aluminum pole products and for welded steel pole products as specified in [Section 1105.01\(g\)3](#). [Bulletin 15](#), shop inspection, and [Section 1105](#) do not apply to painting of aluminum poles and for the following non-welded items: cast aluminum poles, cast steel poles, and cast iron poles.

Certify as specified in [Section 106.03\(b\)3](#).

Permanently mark the following materials with the Manufacturer's Name, Serial Number, and Model or Part Number.

- Controller Units
- Conflict Monitors
- Flashers
- Relays
- Solid-State Load Switches
- Time Clocks
- Time-Based Coordinators
- Coordination Units
- Synchronizers
- Detector Amplifiers
- Detector Power Supplies
- Detector Sensors
- Interfaces
- Modems

Provide switches, controls, and indicators that are operable without the use of tools. Clearly and permanently identify the switches, controls, and indicators.

Furnish three copies of warranties, guarantees, instruction manuals, wiring diagrams, and parts' lists with each different type material. Also, provide in the controller assembly cabinet one instruction manual for each controller unit, time clock, and coordination unit.

Upon completion of a controller assembly, conduct a physical and functional shop test of the assembly's continuous, satisfactory operation, for not less than 5 days. Provide 300 W loads for signal circuit and simulated inputs for detectors, and interconnection. Certify that the equipment operates as indicated. Demonstrate and provide written documentation that the conflict monitor or malfunction management unit will cause transfer of the signals to flashing operation upon sensing all possible conflicting signal indications.

Label the load switch sockets and cable connectors for detector amplifiers, in the controller assembly, according to function.

All equipment which requires a separate device to set, adjust, or read the timing intervals, furnish plans or programs with one of these devices for each ten units or fraction thereof.

1104.02 TRAFFIC SIGNAL SUPPORTS—

(a) General.

1. Design and Acceptance. Design according to the Department's "Criteria for the Design of Traffic-Related Structures." Submit shop drawings according to the Criteria, including calculations for all special structures, for review and acceptance.

2. Supports. Fabricate shafts and arms in any of the following shapes and styles:

Round Tapered.

- One longitudinal seam, continuously welded, and ground or rolled flush.
- Transverse butt welds are not acceptable.
- Uniform wall thickness.
- Uniform taper, 11.7 mm (0.14 inch) maximum and 5.8 mm (0.07 inch) minimum per meter (foot) of length.

Round Stepped.

- Round pipe sections, each with not more than one longitudinal seam continuously welded and ground or rolled flush. Join sections by a hot-swaged shrink fit continuously seal-welded to prevent entrance of water.
- Uniform wall thickness for each section.
- Maximum change in diameter between stepped sections not to exceed 54 mm (2 1/8 inches).

Multi-Sided Tapered.

- Maximum of two longitudinal seams, continuously welded, and ground or rolled to a maximum bead height of 3.2 mm (1/8 inch).
- Transverse butt welds are not acceptable.
- Uniform wall thickness.
- Uniform taper, 11.7 mm (0.14 inch) maximum and 5.8 mm (0.07 inch) minimum per meter (foot) of length.
- Minimum of eight sides.

Round Untapered.

- Maximum of one longitudinal seam, continuously welded, and ground or rolled flush.
- Uniform wall thickness and diameter.

- Transverse butt welds are not acceptable.

3. Support Markings. Stamp the Department approval number on the edge of the base plate of the shaft and the flange plate of the arm. Use letters of 12.7 mm (1/2-inch) minimum height and deep enough to provide clear readability after galvanizing.

4. Cable Support. Weld a cable support to the inside top of the shaft.

5. Grounding. Weld a UL-Listed grounding lug, capable of accommodating a 13.3 mm² (No. 6 AWG) stranded copper cable, to the inside of the shaft adjacent to the handhole.

6. Handholes. Provide a handhole in the shaft of the poles, as shown on the [Standard Drawings](#). Reinforce the area to develop the minimum guaranteed yield strength of the shaft. Furnish a cover and keeper chain.

7. Wire Inlets. Provide a wire inlet at each signal head or at each electrically operated sign location. Weatherproof each inlet with an insulated grommet.

Provide a deburred hole, 63.5 mm (2 1/2-inch) minimum diameter, in the flange plate and shaft, that serves as a wire entrance into the arm from inside the shaft.

8. Anchor Bases.

- Fabricate the base clean, smooth, and of the dimensions necessary for adequate pole mounting and structural support.
- Provide holes for anchor bolts.
- Fabricate the base to telescope over the shaft and be secured in place by welding.

9. Galvanizing. [Section 1105.02\(s\)](#) and as follows:

Galvanize steel shafts and arms, including those manufactured of high strength and corrosion resistant steels, according to ASTM A 123 (AASHTO M 111). Galvanize accessories and hardware according to ASTM A 153 (AASHTO M 232).

(b) Overhead Supports. As shown on the [Standard Drawings](#) and as follows:

- Shaft and Arms—ASTM A 53/A 53M, A 252, A 595, or A 1008
- Luminaire Mounting Arms—[Section 1101.03](#)
- Anchor Bases—One piece steel, AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 250 (Grade 36).
- Flange Plates, Gusset Plates, and Side Plates—AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 250 (Grade 36).
- Flange Plate Assembly Bolts—ASTM A 325
- Shaft and Arm Caps—Galvanized steel (C-coat) cast iron or cast aluminum.

(c) Pedestal Supports. As shown on the [Standard Drawings](#) and as follows:

1. Aluminum.

- Support—One length, 114 mm (4 1/2-inch) minimum outside diameter aluminum pipe, Schedule 40, ASTM B 210/B 210M, or B 221/B 221M, Alloy 6063-T6.

- Bases—Cast aluminum, ASTM B 26/B 26M, or B 108, Alloy 356-T6; aluminum plate, ASTM B 209/B 209M, Alloy 6061-T6.
- Pole Tops—Aluminum

2. Steel.

- Support—One length, 114 mm (4 1/2-inch) minimum outside diameter steel pipe, Schedule 40, ASTM A 53/A 53M, Type F.
- Base—Steel casting, ASTM A 27/A 27M, Grade 450-240 (Grade 65-35); gray iron casting, ASTM A 126, Class B (Class 26); steel plate, AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 250 (Grade 36).

(d) **Anchor Bolts.** As shown on the [Standard Drawings](#) and as follows:

- Anchor Bolts—ASTM A 449.
- Hex Nuts—ASTM A 563M/A 563 (AASHTO M 291)
- Washers—ASTM A 436 (AASHTO M 293)

Galvanize the top 200 mm (8 inches) of bolts and all associated hardware as specified in [Section 1105.02\(s\)](#) (ASTM A 153/A 153M), or by another acceptable method conforming to the coating thickness, adherence, and quality requirements of ASTM A 153/A 153M. Furnish template prints for setting anchor bolts with each support.

(e) **Span Wire.** ASTM A 475, Class A, Siemens-Martin, or ASTM B 416.

(f) **Tether Wire.** ASTM A 475, Class A, Siemens-Martin, or ASTM B 416.

(g) **Lashing.** As shown on the [Standard Drawings](#) for attaching cable to span wire.

1104.03 CONTROLLER ASSEMBLY—

(a) Controller Unit.

1. Electromechanical Pretimed.

1.a NEMA Standards. NEMA TS 1, Section 2 - Environmental Standards and Test Procedures, except temperature.

1.b Operational Requirements.

1.b.1 Dial.

- Temperature Range— -34 °C to 74 °C (-29F to 165F) minimum.
- Type—Plug in.
- Cycle Duration—30 seconds to 120 seconds, in 5-second increments, up to 90 seconds, and 10-second maximum increments, above 90 seconds.

- Cycle Gears—For each controller unit, provide a set of timing gears to obtain cycle lengths from 60 seconds to 100 seconds in 10-second increments. If other cycle lengths are specified, provide additional timing gears as required.
- Dial Divisions—100 positions.
- Keys—Self locking; minimum of 11 advance, one release, and three offset.
- Motor—One per dial; 6 W, synchronous, self-start.
- Splits—One per dial, minimum.
- Settable Offsets—Three per dial, adaptable to dial control.

1.b.2 Camshaft.

- Temperature Range— -34 °C to 74 °C (29F to 165F) minimum.
- Signal Circuits—10 A at 120 V rating; fine silver contacts, rated for a minimum of 1 000 000 operations, functioning at two times per minute; 12 minimum circuits; wire for 19 circuits, including terminal blocks.
- Intervals—12 minimum.
- Actuation Period—200 milliseconds at 30 W.

1.b.3 Chassis.

- Expansible—To three dials.
- Material—Corrosion resistant
- Connector—MS or Jones Type.
- Dust Cover—With dials visible.
- Grounding—With ac ground isolated from chassis ground.

1.c Interconnect—7-Wire System.

- Offsets—1, 2, and 3.
- Cycles—Call Dial 2; Call Dial 3.
- Flashing—Remote flashing.
- Voltage—95 V to 135 V (ac), 57 Hz to 63 Hz.
- Input—Positive true.
- Fuse—Ampacity, per manufacturer's recommendations.
- Isolation—Remote common from local ground.

2. Solid-State Pretimed.

2.a NEMA Standards.

- TS 1, Section 2, Environmental Standards and Test Procedures.
- LI-1, Type FR-4, Circuit Boards.

2.b Operational Requirements.

- Cycles—Three minimum.
- Splits—One per cycle minimum.
- Settable Offsets—Three per cycle.
- Cycle Duration—30 seconds to 120 seconds, in 1-second increments.
- Signal Circuits—12 minimum, wired for 18, including terminal blocks.

2.c Interconnect.

- Offsets—1, 2, and 3.
- Cycle—Call Cycle 2; Call Cycle 3.
- Flashing—Remote flashing.
- Voltage—95 V to 135 V (ac), 57 Hz to 63 Hz.
- Input—Positive true.
- Fuse—Ampacity per manufacturer's recommendations.
- Isolation—Remote common from local ground.

3. Solid-State Actuated.

3.a NEMA Standards.

- TS 1, Section 2, Environmental Standards and Test Procedures.
- TS 1, Section 13, Interface Standards.
- TS 1, Section 14, Solid-State Traffic Signal Controller Units.

4. **Solid-State Actuated with Volume Density.** Section 1104.03(a)3 and with the following operational requirements:

Functions.

- Variable Initial Timing—Maximum variable initial timing programmable from 0 to 60 seconds.
- Gap Reduction Timings—As indicated.

5. Solid-State Flasher.

- Flasher—[Section 1104.03\(c\)2](#)
- Circuit Breaker—[Section 1104.03\(g\)1](#)
- Surge Protector—[Section 1104.03\(g\)2](#)
- Cabinet—[Section 1104.03\(j\)](#), except auxiliary door for police panel, filter, and fan are not required.

(b) Conflict Monitor.

1. Electromechanical Controller Units. Capable of detecting the presence of conflicting green signal indications and then causing the transfer of the signal to flashing operation. Signals are to remain flashing until manually reset. Do not reset by interruption of power to the unit.

2. Solid-State Controller Units. NEMA Standards TS 1, Section 6, Conflict Monitors. A minimum of one input channel for each load switch socket as specified in [Section 1104.03\(j\)](#).

(c) Flasher.**1. Electromechanical Controller Units.**

- Contacts—20 A, Fine Silver or Silver Alloy, rated for 1 000 000 operations.
- Motor—5 W, Non-synchronous, self starting.
- Flashing rate—54 flashes per minute to 64 flashes per minute, 50% duty cycle.
- Connector—Jack mounted.

2. Solid-State Controller Unit. NEMA Standard TS 1, Section 8, Solid-State Flashers.

(d) Relays.

1. Light Duty Relay. Mounted in a clear, plastic cover, permanently marked to indicate coil voltage rating, and as follows:

- Usage—Logic, Preemption or Interconnection.
- Voltage—115 V (ac) or 24 V (dc).
- Switch Type—TPDT or DPDT.
- Contact Rating—2 A.
- Contact Material—Fine Silver or Silver Alloy.

2. Heavy Duty Relay. Mounted in a clear, plastic cover, permanently marked to indicate coil voltage rating, and as follows:

- Usage—Continuous Duty-Transfer of signal indications from normal operation to flashing and the reverse.

- Voltage—95V to 135 V (ac), 57Hz to 63 Hz.
- Switch Type—DPDT.
- Contact Reading—20 A.
- Contact Material—Fine Silver or Silver Alloy.
- Standard Socket—8 Pin, Jones Type.

3. Mercury Displacement Relay. With a hermetically-sealed, mercury retainer, permanently marked to indicate coil voltage rating, and as follows:

- Usage—Power on/off.
- Coil Rating—95V to 135 V (ac), 57Hz to 63 Hz.
- Nominal Coil Current—65 mA.
- Operating Time—50 milliseconds.
- Release Time—80 milliseconds.
- Temperature Range— -34 °C to 74 °C (-29F to 165F).
- Dielectric Strength—2500 V (rms).
- Insulation—Class B, 130 °C (266F).
- Contact Rating—30 A min., SPST normally open.

4. Dial Transfer (Latching Relay). Mounted in a clear plastic cover, permanently marked to indicate coil voltage rating, and as follows:

- Usage—Dial Transfer.
- Voltage—95-135 V (ac), 57 to 63 Hz, 9 W.
- Switch Type—TPDT Electric Latching (two external poles), DPDT Mechanical Latching.
- Contact Rating—1 A.
- Contact Material—Fine Silver or Silver Alloy.
- Standard Socket—Plug, interchangeable with furnished base.

(e) Load Switches. According to NEMA TS 1, Section 5, Solid-State Load Switches. Provide LED indicators to display operation. Isolate signal load from load switch input using optic couplers. Furnish a minimum of one load switch for each of the following active controller unit functions:

- Vehicle Phase.
- Overlapping Vehicle Phase.

- Subordinate Pedestrian Phase.

(f) Cable Terminal/Harness Assembly. For wiring the cabinet, including connections to the electrical load center, police panel switches, signal load switches, signal cable terminals, controller unit, conflict monitor, detectors, and relays, and as follows:

- Connectors—Non-interchangeable between controller units, load switches, and flashers.
- Wiring—Arrange and lace or enclose in a raceway or in plastic tubing.
- Terminal Blocks—Barrier-type, with marker strips and nickel-plated brass screws, 8-32 x 7.94 mm (5/16-inch) minimum for detector leads, 10-32 x 7.94 mm (5/16-inch) minimum for signal leads, rated for 20 A at 1000 V (rms).

(g) Electrical Load Center.

1. Breakers and Receptacles.

- Circuit Breakers—15 A minimum, flashing circuit and duplex receptacle. 15 A minimum, traffic control equipment.
- Duplex Receptacle—NEC-Type, Ground Fault Interruptor, with test buttons.

2. Power Line Surge Protectors. UL-Listed, rated for a maximum permissible line to ground voltage of 175 V (rms).

3. Radio Frequency Interference (RFI). UL-Listed, RFI filter, according to NEMA standard testing procedures, and as follows:

- Line Voltage—95 V to 135 V (ac).
- Line Frequency—57 Hz to 63 Hz.
- Line Current—125% of the total connected load, 30 A minimum.
- Operating Temperature—-34 °C to 74 °C (-29F to 165F).
- Insulation Resistance—6,000 megaohms.
- Line to Ground Rating—1500 V (ac), one minute.
- Line to Line Rating—1450 V (dc), one minute.
- Humidity Range—5 % to 95 %, relative.
- Maximum Filter Limit—150 kHz.
- Overload—360 A, for 8 minutes.

(h) Preemption Equipment. A preemptor that provides the indicated clearance and operational intervals and as follows:

- Solid-state components with solid-state controller unit.
- Electrical-mechanical or solid-state components, with electrical-mechanical controller unit.

- An integral, but dedicated module of the controller unit or a shelf-mounted chassis connected to the controller unit with a MS connector.
- A timing control able to be set for each preemption interval.
- An indicator light for each preemption interval.
- Momentary contact switch in the actuation circuit for testing the preemptor.
- Operates only when actuated by the preemption circuit or by the test switch.
- Delay timers, adjustable from 0 seconds to 60 seconds minimum, with manually operated emergency vehicle preemptors.

(i) Police Panel. Furnish with the following switches:

- Auto—Flash
- Lights (ON—OFF)
- Auto—Manual

(j) Cabinet. Furnish a weatherproof controller cabinet, large enough to suitably house the traffic signal controller unit and auxiliary equipment, and conforming to the following requirements:

1. Enclosure.

- Material—Sheet or cast aluminum.
- Wall Thickness—3 mm (1/8 inch) minimum, reinforced where required.
- Minimum Size—As shown on the [Standard Drawings](#) and as follows:
Position equipment in the cabinet to provide access to all terminal strips and equipment from the front without removing other equipment. Provide an unobstructed view of all equipment having visual indicators. Place all equipment in an upright position and not on top of other equipment.
- Hardware—Vandal and corrosion resistant.
- Finish—Natural with external welds free of irregularities and a maximum bead height of 3.2 mm (1/8 inch).
- Gaskets—Neoprene, attached with an oil resistant adhesive.
- Mountings—As indicated, pole or foundation.
- Locks—Brass, tumbler type for main door and standard police lock for auxiliary door; two keys for each lock.
- Door—Hinged on right side, door stop at 90 degrees and 180 degrees, ± 10 degrees, for all doors over 460 mm (18 inches) wide, auxiliary door for access to police panel, pocket for prints.
- Latching Mechanism—One point-through mechanism for doors less than 555 mm (22 inches) in width; three point-through mechanism for doors 555 mm (22 inches) or wider.

- Interior—Shelf-mounted equipment, unless rack or panel-mounted.
- Test Pushbutton Panel—One pushbutton to each input for simulated detector operation of vehicles and pedestrians with type and phase permanently labeled on panel. Mount panel on inside of door.

Back panels, wiring and terminals for maximum phase capability of solid-state controller unit, load switch sockets as required and as follows:

Controller Unit	Load Switch Sockets	
	Minimum Number	Maximum Number
Pretimed	6	As required
2 Phase Actuated	4	As required
2-4 Phase Actuated	8*	12
2-8 Phase Actuated	12*	20

* Provide a minimum of two unused sockets per unit.

2. Environmental Controls.

2.a General.

- Ventilation—Weatherproof vents of sufficient area in the lower part of the door or cabinet.
- Filter—Cover vents with a disposable filter securely held in place.

2.b Solid-State Equipment.

- Fan—Capacity; 47 L/s (100 cfm) minimum.
- Fan Thermostat—Line-voltage type, adjustable from 33 °C to 65 °C (91F to 149F), with 6 °C (43F) turn off below on position.

(k) Time Clock, Solid-State. Enclosed in an electrical-shockproof housing, conforming to the following requirements.

- Input Voltage—95 V to 135 V (ac), 57 Hz to 63 Hz.
- Output Voltage—95 V to 135 V (ac), 57Hz to 63 Hz.
- Output Current—5 A.
- Output Circuits—As required.
- Output Setting Limit—10 minutes.
- Skip-Feature—7 day.
- Carryover—24 hours minimum.
- Clock Setting Limit—1 second.
- Time Sets—One on-off/day/circuit.
- Temperature— -34 °C to 74 °C (-29F to 165F).

- Transient Immunity—Varistor.
- Humidity—5% to 95% relative.
- Daylight Savings Time—Automatic transfer.

1104.04 SYSTEMS—

(a) Time-Based Coordinator Unit.

1. Type. As required to interface with controller unit having ac or dc input/output. If being placed in an existing traffic signal system, make compatible with the existing time-based coordinators in that system.

2. NEMA Standards.

- TS 1-2.1.1, Operating Voltage, Frequency, and Power Interrupt.
- TS 1-2.1.2, Voltage.
- TS 1-2.1.3, Frequency Range.
- TS 1-2.1.5, Temperature and Humidity.
- TS 1-2.1.6, Transients, Power Service.
- TS 1-2.1.12, Vibration.
- TS 1-2.1.13, Shock.
- TS 1-13.2, Electrical Limits of Input/Output.

3. Provisions for Timing Plans.

- Storage Capability—Nine, settable, timing programs; (minimum) one dedicated free-operation program; and three control programs.
- Settable Program Positions (minimum)—One Offset; One Cycle; One Split
- On/Off Output Switch—One per control program.
- Program Assertion—Turn-off previous settable or free programs at the assertion of any of the settable or free, operational programs.

4. Cycle.

- Number—Three, minimum.
- Duration—Settable range of at least 30 seconds to 180 seconds.
- Increments—5 second maximum.

5. Clock/Calendar.

- Resolution—1 second.
- Selectable Programs—Day of week/hour/minute/second
- Number of Changes—50 minimum per day.
- Daylight Savings Time—Automatic transfer.
- Accuracy— ± 0.005 (50 ppm)% of clock calendar time, with respect to real time.

6. Display. A type having a 6 mm (1/4-inch) minimum digital readout and capable of displaying the following: day of week, hour, minute, second, program in effect, and setting stored or entered for storage.

7. Battery Backup.

- Memory Functions—Clock/calendar program settings.
- Memory Retention—48 hours, minimum.
- Charger—Automatic trickle type, complete recharge in 24 hours.
- Rated Life—Minimum of 5 years.
- Indicators—Battery failure.

8. Inputs.

- Power Requirements—95 V to 135 V (ac), 57 Hz to 63 Hz.
- Minimum Number and Type—Eight green-signal inputs at 24 V (dc), negative true.
- Keyboard—Front panel mount.
- Transfer Function—Input program from other unit.

9. Outputs.

- Minimum Number—As required to provide the time controlled functions indicated. Eight minimum.
- Settable Outputs—Offset 1; Offset 2; Offset 3; Call Cycle 2; Call Cycle 3.
- Special Control Functions (As indicated)—Sign Control; Remote Flashing.
- Transfer Function—Output program for input to other units.

10. Program Transition. Pretimed Controller Units

- Dwell in coordinated phase walk.
- Dwell not to exceed 25% of operating cycle.

- Dwell in called-cycle when cycle transfer occurs due to program change.
- Program transfer, not to exceed four cycles.

(b) Master Controller Assembly.

1. Master Controller Unit.

1.a Electromechanical Pretimed. Capable of functioning as an intersection controller or as a master controller to supervise other intersection controllers and as follows:

- Number of Cycles—Three.
- Offset Functions—Designed for master operation.
- Manual Dial Selection Switch—System.
- Five Dial Time Switch
 - Switch 1 and 2 Off—Offset 1
 - Switch 2 On—Offset 2
 - Switch 1 On—Offset 3
 - Switch 1 and 2 On—Offset 3
 - Switch 3 On—Flashing, overrides all other switch positions.
 - Switch 4 On—Cycle 2
 - Switch 5 On—Cycle 3
 - Switch 4 and 5 On—Cycle 1
- Output Circuits—Rated for 10 A at 95 V to 135 V(ac).

1.b Solid-State, Pretimed. Capable of functioning as an intersection controller or as a master controller to supervise other intersection controllers and as follows:

- Output Circuits—Ground true.
- Time Switch—[Section 1104.04\(b\)1.a](#) for functions.
- Manual Pushbutton—For sync function with master removed.

2. Conflict Monitor. [Section 1104.03\(b\)](#)

3. Flasher. [Section 1104.03\(c\)](#)

4. Relays. [Section 1104.03\(d\)](#)

5. Load Switches. [Section 1104.03\(e\)](#)

6. Cable Terminal/Harness Assembly. [Section 1104.03\(f\)](#)

7. Electrical Load Center. [Section 1104.03\(g\)](#)

8. Police Panel. [Section 1104.03\(i\)](#)

9. Cabinet. [Section 1104.03\(j\)](#)

(c) Coordination Unit.

1. Electromechanical. Capable of coordinating up to an eight-phase, dual-ring, solid-state, actuated controller unit and as follows:

1.a Dial.

- Cycle Length—As indicated, in 5-second increments up to 90 seconds and 10-second maximum increments above 90 seconds.
- Switch—Function by snap-in-place dial keys.
- Transfer—At a point in the cycle common to all three splits.
- Force-Off—Provide means to ensure force off for each ring, terminating the intended phase.
- Spare Cycle Gears—For each coordination unit, provide a set of timing gears to obtain cycle lengths from 60 seconds to 100 seconds in 10-second increments. If other cycle lengths are specified, provide additional timing gears as required.

1.b Interface. NEMA TS 1, Section 13.

1.c System Interconnection.

- Type—Standard seven-wire positive subsystem.
- Function Requirements—95 V to 135 V (ac), 57 Hz to 63 Hz with isolated remote-common.

1.d Grounding.

- Chassis Safety Ground—Connect exposed metal surfaces.
- Internal Connections—None between chassis safety ground, remote-common, ac ground, and logic-ground.

1.e Environment. NEMA TS 1, Section 2.

2. Solid-State. Capable of coordination up to an eight-phase, dual-ring, solid-state, actuated controller unit and as follows:

2.a Cycle.

- Length—As indicated, in 1-second increments.
- Force-Off—Ensure the force-off command is directed to correct phase.
- Cycle and Split Transfer—At 0% point in local cycle.
- Offset Transfer—With pedestrian control, transfer in “green/walk” interval. With nonpedestrian control, transfer in “green.” Transfer to occur in a maximum of three cycles with no more than 17% change in any one cycle.

2.b Interface. NEMA TS 1, Section 13.

2.c System Interconnection.

- Type—Standard, seven-wire, positive subsystem.
- Function Requirements—95 V to 135 V (ac), 57 Hz to 63 Hz with isolated ground.

2.d Environment. NEMA TS 1, Section 2

(d) Electromechanical Synchronizer Unit. A one-dial unit, capable of coordinating up to an eight-phase, dual-ring, solid-state, actuated controller unit and as follows:

- Number of Background—One cycles.
- Motor—Synchronous, self-starting.
- Power Requirements—95 V to 135 V (ac), 57 Hz to 63 Hz.
- Power Consumption—6 W maximum, fused.
- Case—Shockproof, use chassis safety ground, connected to case.
- Electric Connection—None between logicground, ac-ground, remote-common, and chassis safety-ground inside the synchronizer.
- Hold Circuit—Connected to logic-ground on one side of switch.
- Disconnect Plug—Compatible to control equipment, with external connector and harness.

1104.05 ELECTRICAL DISTRIBUTION—**(a) Conduit.**

1. Rigid Steel Conduit. [Section 1101.09](#), except may be used for direct burial, and UL-6 Listing for rigid metallic conduit, galvanized inside and outside.

2. Rigid Polyvinyl Chloride Conduit. [Section 1101.09](#) with UL-651 Listing for rigid nonmetallic conduit, and UL 514 Listing for fittings.

3. Cable Pulling Lubricant. [Section 1101.12\(c\)](#)

4. Conduit Sealant. An acceptable duct seal.

(b) Wire and Cable.

1. Signal Cable. 2.08 mm² (14 AWG) minimum, stranded conductors; conforming to IMSA Specification 19-1 or 20-1.

2. Service Wire. 8.37 mm² (8 AWG) minimum wire, Type USE conforming to UL-854 Listing and ASTM B 3 and B 8 for soft, annealed copper.

3. Ground Wire. Bare or insulated (green) copper wire, 8.37 mm² (8 AWG), conforming to ASTM B 3.

4. Cable Tags. [Section 1101.12\(d\)](#)

5. Cable Ties. An acceptable type.

(c) Junction Box. Furnish the type indicated and as follows:

- Precast Junction Box—[Section 714](#)
- Steel or Cast-Iron Junction Box—steel or cast iron conforming to the requirements for cast-iron junction box, [Section 1101.10](#).
- Reinforced Plastic Mortar Junction Box—Reinforced plastic mortar box with a nonskid cover, providing a watertight connection to the housing when installed.

(d) Electrical Service.

1. **Service Pole.** [Section 1101.11\(a\)](#)
2. **Service Head.** UL-Listed weatherproof service head, for applicable conduit type.
3. **Meter Socket.** As specified by the utility company.
4. **Service Disconnect.**

4.a Enclosure. Galvanized steel, aluminum, or stainless steel, with a hinged door having provisions for a padlock and no external handles or switches; conforming to the NEMA Standard for Type 3R, Type 3S, or Type 4. Provide a brass padlock for outdoor use, with two keys. All padlocks shall be keyed alike.

4.b Main Disconnect. Provide a means for disconnecting the service conforming to NEC.

4.c Fuses. UL-Listed Type K-1, 30 A minimum.

4.d Fuse Block. UL-Listed for K-1 fuses.

4.e Power Line Surge Protector. [Section 1104.03\(g\)2](#)

(e) Wire Connectors.

1. **Wire Nuts.** Insulated, UL-Listed, with spring insert for applicable wire size and rating of wire insulation.
2. **Waterproof Resin Sealer.** Insulated, UL-Listed for wire nuts.

3. Terminal Blocks. UL-Listed with twelve-sets minimum to two terminals each, screw-type, rated at a minimum of 600 V, and suitable for the applicable wire size. Connect each set of terminals by means of a removable link. Separate each set of terminals by a molded barrier. Provide a marker strip for terminal identification.

4. Insulated Locking Spade Terminals. An acceptable type.

(f) Grounding Bushings and Lugs.

1. **Bushings.** UL-Listed for applicable conduit type and size.
2. **Lugs.** UL-Listed for applicable materials.

(g) Ground Rods With Clamp. [Section 1101.11\(j\)](#)

1104.06 SIGNAL HEADS—

(a) Vehicular Signal Heads. Conforming to the ITE Standard for “Adjustable Face Vehicular Traffic Control Signal Heads,” the regulations, and as follows:

1. Housings.

- Plastic—Opaque polycarbonate resin molding, conforming to ASTM D 3935. Federal yellow in color, except the inside of the visor, which will have a non-reflective black finish.
- Aluminum—Finish exterior of aluminum housings as follows:

Clean and coat surfaces of the signal housing, door, and visor, with an infrared, oven-baked, iron-oxide backing primer, conforming to Federal Specification TT-P-1757B and Federal Specification SSPC-Paint 25.

Coat finished surfaces, except the inside of the visor, with infrared, ovenbaked, highway yellow exterior enamel, conforming to , according to Federal Standard No. 595B. Finish the inside of the visor with phthalic anhydride, black, synthetic baking enamel, with zero gloss reflectance and conforming to the performance requirements of MIL-E-5557 Enamel Heating Resisting Glyceryl Phthalate, Type 4, Instrument Black.

2. Reflectors. Polycarbonate or aluminum. When the reflector is attached to the door, provide a means by which opening the door disables the indication.

3. Lamps. Furnish incandescent lamps conforming to ITE Standard for Traffic Signal Lamps and as follows:

	Lens Diameter	
	200 mm (8-inch)	300 mm (12-inch)
Rated Voltage	120	120
Rated Life-Hours	6000	6000
Rated Initial Lumens	595	1750
Light Center Length, mm (inches)	62 (2 7/16)	76 (3)

4. Miscellaneous. Furnish cut-away visors unless otherwise indicated. Furnish louvers and backplates as indicated, with a non-reflective black finish.

(b) Optically Programmed Signal Heads. Conforming to the regulations and as follows:

1. Optical. Incorporate an optical system that limits the visibility zone internally and optically, without the use of hoods or louvers. The projected signal may be visible or selectively veiled anywhere within 15 degrees of the optical axis.

2. Sections. Provide an integral means for the incremental tilting of each section, from 0 degrees to 10 degrees above and below the horizontal. Unless directed otherwise, assemble vertically-mounted signals with a 4-degree tilt below the horizontal. Provide couplers, serrated locking rings, flanges, gaskets, and other hardware necessary to mate optically programmed signal sections together or to mate with nonoptically programmed sections, all in a secure and weathertight manner. Shop-join the sections. Use corrosion resistant internal hardware.

3. Painting. [Section 1104.06\(a\)1](#)

4. Electrical. Use copper, brass, nickel-plated brass, or phosphor-bronze, electrical-conducting hardware. Furnish lamps that provide luminous intensity of 950 cd (950 beam candlepower), conforming to the traffic signal manufacturer's specification, rated at a minimum of 6000 hours. Color code the internal wiring. Provide a breaker that disables the indication when the lamp door is opened.

Provide an integral means within each signal face for regulating its luminous intensity between limits, in proportion to the individual background illumination, but not less than 97% of uncontrolled intensity at 10 764 lx (1,000 footcandles); and reduce to $15\% \pm 2\%$ of maximum intensity at less than 10 lx (1 footcandle), proportionally and instantaneously.

5. Miscellaneous. Furnish cut-away visors. Furnish optical programming material and instructions. Within each section, affix a permanent, conspicuous warning label, advising of possible eye damage and fire hazard from the sun.

(c) Pedestrian Signal Heads—Incandescent. Conforming to the ITE Standard for “Adjustable Face Pedestrian Signal Heads,” the regulations, and as follows:

1. Housings. [Section 1104.06\(a\)1](#)

2. Reflectors. [Section 1104.06\(a\)2](#)

3. Lamps. Furnish incandescent lamps conforming to ITE Standard for Traffic Signal Lamps and as follows:

	Type A	Type B
Rated Voltage	120	120
Rated Life-Hours	6000	6000
Rated Initial Lumens	595	1260
Light Center Length, mm (inches)	62 (2 7/16)	62 (2 7/16)

4. Miscellaneous. Furnish cut-away visors, unless otherwise indicated.

(d) Pedestrian Signal Head-Fiber Optic, Halogen, or Neon. Conforming to ITE Technical Report 5, the regulations, and as follows:

1. Housing. A weatherproof die-cast aluminum, rectangular housing, complete with a hinged door, door frame with gasket, visor, glass fiber optic module, color filters, light-source lenses, transformers, and face plates with the indicated legends.

2. Electrical. Maximum operating power consumption per message not to exceed the following:

- Neon 100 W
- Fiber optic 50 W
- Halogen 90 W

Where the reflector is attached to the door, provide a means by which opening the door of a signal disables the indications.

3. Optical. Use filters to correct colors. “WALK” legend to be lunar white and “DON'T WALK” legend to be Portland orange. Under any ambient light conditions, phantom words are not to be visible when the signal is not energized.

(e) Lane-Use Traffic Control Signal Heads. Conforming to the ITE Standard for Lane-Use Traffic Control Signal Heads, the regulations, and as follows:

1. Housings. For plastic, use Federal yellow opaque, polycarbonate-resin moldings, conforming to ASTM D 3935.

2. Lamps. For incandescent, provide lamps with 1750 rated initial lumens, with a 76 mm (3-inch) light center length, and rated at a minimum of 6000 hours of average life.

(f) Mounting Assembly and Hardware. Furnish signal mounting assemblies and hardware of a type and design that adequately supports the loading indicated.

1104.07 DETECTORS—

(a) General.

1. Sealant. Furnish a nonshrinking and nonshrinking, flexible sealant for the encapsulation of loop or magnetometer sensor and as follows:

- Number of Components—One or two
- Application Temperature—0 °C to 38 °C (32F to 100F)
- Tack Free—1 hour maximum
- Maximum Curing Time—30 hours
- Permanent Flexibility—to -29 °C (-20F)
- Chemically Resistant To:
 - De-Icing Chemicals
 - Gasoline
 - Calcium Chloride (5%)
 - Motor Oils
 - Hydraulic Brake Fluid

2. Detector Lead In Cable. 2.08 mm² (14 AWG) minimum conforming to IMSA Specification 50-2.

3. Card Rack Assembly.

3.a Power Supply. Furnish a switching-type power supply and as follows:

- Input Voltage—95 V to 135 V (ac), 57Hz to 63 Hz
- Output Voltage—24 V ± 0.3 V (dc)
- Minimum Output Voltage—22.8 V (dc)
- Efficiency—70% minimum
- Full Load Current—3 A minimum
- Line Regulation—0.1% over entire input range
- Load Regulation—0.2% from no load to full load
- Ripple Noise—40 mV (p-p) typical, 75 mV (p-p) at full load
- Environmental—NEMA TS 1, Part 2

Provide a front panel incorporating a pilot lamp, test points for monitoring output voltage, and a circuit breaker or fuse. Ground all exterior metal surfaces to the chassis safety ground.

3.b Card Rack. A standard EIA, 483 mm (19-inch) rack for mounting the detector amplifier units, as follows:

- Aluminum front rails, drilled and tapped (10-32), with EIA spacing.
- Aluminum chassis supporting angles, 254 mm (10 inches) deep and 76 mm (3 inches) wide, for mounting on the sides of the controller cabinet.
- Aluminum connector panels, with connector mounting holes, tapped (4-40) on 5 mm (0.200-inch) centers, then mounted to form a cage 483 mm (19 inches) wide, 134 mm (5 1/4 inches) high, and 165 mm (6 1/2 inches) deep.
- Nonmetallic guides and Cinch-Jones No. 50-44A-30M rear connectors, mounted at 30.5 mm (1.200-inch) spacings.

4. Re-Enterable Splice Kit. Reusable molded body, internal and external hardware, clear polyurethane compound. Provide an appropriate size to accommodate in-line, wye, “x,” butt, and dead-end splicing of cables rated at 1000 V or less, with outside diameters from 6.35 mm (0.25 inch) through 63.5 mm (2.50 inches). Supply with the following components:

- Two-part transparent mold body of PVC construction, with tongue-and-groove seams and built-in spacer web.
- Two flexible end caps, each with double-stepped cable entry ports to accommodate the many possible splicing configurations.
- Snap-in caps to cap off the fill ports, after compound pouring.
- Strain bars with insulator sleeves.
- Four shield connectors to provide shield continuity, with strain bars for shielded cables.
- Stainless steel base clamps to secure splice body, end caps, and strain bars.
- Re-enterable electrical insulation and sealing compound, capable of continuous operation at 90 °C (194F), with an emergency overload temperature rating at 130 °C (266F), a viscosity of approximately 1.1 Pa·s (1,100 centipoise) at 26 °C (79F), a gel time of approximately 20 minutes at 23 °C (73F), and zero growth fungus resistance, according to ASTM G 21.
- An instruction booklet, showing proper installation and re-entry techniques.

(b) Loop Detector.

1. Loop Sensor. 2.08 mm² (14 AWG) minimum, conforming to IMSA Specification 51-5.

2. Loop Amplifier, Shelf-Mounted. Self-tuning, loop amplifier, shelf-mounted, enclosed in a shock-proof housing with relay output and one or two channels as indicated, conforming to NEMA TS 1, Section 7.

3. Loop Amplifier with Timers, Shelf-Mounted. Self-tuning, loop amplifier, shelf-mounted enclosed in a shock-proof housing with relay output and one or two channels as indicated, conforming to NEMA TS 1, Section 11.

4. Loop Amplifier, Rack-Mounted. Self-tuning, loop amplifier, mounted on an edge-connected, printed circuit board with an electrically isolated solid-state output and two or four channels as indicated, conforming to NEMA TS 1, Section 7.

5. Loop Amplifier with Timers, Rack-Mounted. Self-tuning, loop amplifier, mounted on an edge-connected, printed circuit board with an electrically isolated solid-state output and two or four channels as indicated, conforming to NEMA TS 1, Section 11.

(c) Magnetometer Detector.

1. Magnetometer Sensor. As indicated and as follows:

- Physical Size—Cylindrical housing, nonferrous, moisture-proof, suitable for direct burial in roadway pavement, with no damage due to subsurface stresses, and with a lead-in cable of proper length for hookup.
- Operational—No moving parts and compatible with the magnetometer detector amplifiers furnished.

2. Magnetometer Amplifier, Shelf-Mounted. Enclosed in a shock-proof housing and as follows:

- Operation—Solid-state design with two independent detection channels in each unit, designed so the sensing element of one channel has no effect on the other.
- Bimodal—Pulse mode—Provides an output closure of $125 \text{ ms} \pm 25 \text{ ms}$ duration for each vehicle entering the detection area.

Bimodal—Presence mode—Continually indicates the presence of a vehicle, until the vehicle leaves the area of detection, at which time the indication is to cease within 100 ms.

- Sensing Elements—One to six magnetometer sensors per channel capability at a distance of up to 915 m (3,000 feet) between sensor and amplifier.
- Indicators and Switches—Provide on front panel: an LED indicator, sensitive to vehicle detection; fused or circuit breaker overcurrent protection; mode switch, calibration controls; and switch or switch position per channel for disabling the output of a channel and placing a call on a channel.
- Output—Optically isolated Darlington—An opto-isolated, NPN open collector capable of sinking 50 mA at 30 V (dc).
- Connector—MS-3106A20-29P, 17-pin connector with the following pin assignments:

		Channel 1		Channel 2
	White	D		T
	Black	E		N
Probe Sets	Red	P		J
	Green	R		S
	Common (-)	B		K
Output	Detect (+)	G		M
	Neutral		A	
ac Power	High		C	
	Chassis Ground		H	

- Power Requirements—Maximum 11 V·A at 105 V to 125 V (ac), 57 Hz to 63 Hz without originating, nor being susceptible to, electrical transients in excess of the NEMA, TS 1, Section 2.
- Environment—NEMA TS 1, Section 2.

3. Magnetometer Amplifier, Rack-Mounted. Mounted on an edge connected, printed circuit board for rack-mounting and as follows:

- Physical—Provide a hand pull to facilitate insertion and removal from the rack.
- Operation—[Section 1104.07\(c\)2](#)
- Modes—[Section 1104.07\(c\)2](#)
- Sensing Elements—[Section 1104.07\(c\)2](#)
- Indicators and Switches—[Section 1104.07\(c\)2](#), excluding overcurrent protection.
- Output—[Section 1104.07\(c\)2](#)
- Connector—Cinch Jones Number 50-40-A-30M, 22-pin edge connector, with the following pin assignments:

Pin Function

A	dc Ground
B	+24 V (dc)
C	Reset
D	Sensing Element #1 Input
E	Sensing Element #1 Input
F	Control Unit Output #1 (Collector)
H	Control Unit Output #1 (Emitter)
J	Sensing Element #1 Excitation
K	Sensing Element #1 Excitation
L	Equipment Ground
M	Reserved
N	Reserved
P	Sensing Element #2
R	Sensing Element #2
S	Control Unit Output #2 (Collector)
T	Control Unit Output #2 (Emitter)
U	Sensing Element #2 Excitation
V	Sensing Element #2 Excitation
W	NA
X	NA
Y	NA
Z	NA

Connector—Slotted for keying (Between Pins B&C and Pins M&N).

- Power Requirements—Maximum current 300 mA from 33 V to 28 V (dc).
- Environmental—NEMA TS 1, Section 2.

(d) Magnetic Detector.**1. Magnetic Sensor.**

- Physical—Cylindrical case, nonferrous, moisture-proof, suitable for burial within rigid nonmetallic conduit, and with a lead-in of sufficient length.
- Operation—No moving parts and compatible with the magnetic-detector amplifier furnished.

2. Magnetic Amplifier, Shelf-Mounted. Shelf-mounted, enclosed in a shock-proof housing, and as follows:

- Operation—Solid-state design, with one channel in each unit.
- Sensing Elements—One or more magnetic sensor capability at a distance of up to 305 m (1,000 feet) between the sensor and amplifier.
- Indicators and Switches—Provide on front panel: indicator for detection of a vehicle, fused or circuit breaker overcurrent protection, calibration controls, and a switch or switch position for disabling the output and placing a call.
- Output—[Section 1104.07\(c\)2](#)
- Connector—Relay output—MS3106A-18-1S, Solid-State (Isolated)—MS3106A-8-15W.
- Power Requirements—Maximum power consumption of 2 W at 120 V (ac) and 60 Hz.
- Environmental—NEMA TS 1, Section 2.

3. Magnetic Amplifier, Rack-Mounted. Mounted on an edge-connected, printed circuit board for rack-mounting and as follows:

- Physical—With a handpull to facilitate insertion and removal from the rack. The four-channel, magnetic-detector amplifier in the front panel space of two, two-channel magnetic-detector amplifiers.
- Operation—Solid-state design with two or four independent detection channels in each unit, as indicated, designed that the sensing element of one channel has no effect on the other.
- Sensing Element—One or more magnetic sensors per channel, capable of sensing at a distance of up to 305 m (1,000 feet) between the sensor and amplifier.
- Indicators and Switches—[Section 1104.07\(c\)2](#), excluding overcurrent protection.
- Output—[Section 1104.07\(c\)2](#)
- Connector—Cinch-Jones Number 50-40-A-30M, 22-pin edge connector, with the following pin assignments:

Pin Function

A	dc Ground
B	+24 V (dc)
C	Not Connected
D	Detector #1 Element

E	Detector #1 Element
F	Detector #1 Output (C)
H	Detector #1 Output (E)
J	Detector #2 Element
K	Detector #2 Element
L	Chassis Ground
M	Reserved
N	Reserved
R	Detector #3 Element
S	Detector #3 Output (C)
T	Detector #3 Output (E)
U	Detector #4 Element
V	Detector #4 Element
W	Detector #2 Output (C)
X	Detector #2 Output (E)
Y	Detector #4 Output (C)
Z	Detector #4 Output (E)

Connector—Slotted for keying

(C)—Collector

(E)—Emitter

- Power Requirements—Maximum of 60 mA per channel from a 24 V (dc) power supply.
- Environmental—NEMA TS 1, Section 2.

4. Rigid, Nonmetallic Conduit. [Section 1104.05\(a\)2](#)

(e) Pedestrian Pushbutton. Capable of completing a momentary circuit closure and as follows:

- General—Furnish a tamper and weatherproof assembly with pushbutton contacts, entirely insulated from the housing and buttons. Furnish sign and mounting assembly as indicated. Conform to the regulations for the sign legend and [Section 1103.04](#) for the fabrication. Use stainless steel hardware to mount the pushbutton assembly.
- Housing—Die-cast aluminum alloy housing, with a curved back or a flat back as required to conform to the mounting surface. Paint the assembly highway yellow, as specified in [Section 1104.06\(a\)1](#). Provide a rear cable entry.
- Electrical—Provide a switch mechanism consisting of a direct push-type button, with a single momentary contact switch, contacts rated at 10 A minimum, 125 V (ac) for operation at 24 V (dc).

1104.08 COMMUNICATIONS—

(a) Control Cable. Furnish control cable conforming to IMSA Specification 19-1 or 20-1 for cable in conduit and IMSA Specification 20-3 for aerial cable. Provide stranded conductors, 2.08 mm² (14 AWG), minimum.

(b) Communication Cable. Furnish communication cable conforming to IMSA Specification 19-2 or 20-2 for cable in conduit and IMSA Specification 20-4 for aerial cable. Provide as indicated, stranded conductors, 0.65 mm² (19 AWG), minimum.

(c) Instrument Cable. Shielded cable with three solid 0.517 mm² (20 AWG) conductors and one drain wire and as follows:

- Insulation—Moisture and heat resistant (75 °C (167F)) polyethylene conforming to ASTM D 1248, Type I, Class B, Category 5, Grade E4, 600 V rating applied concentrically about the conductor.
- Color Code—(1) yellow, (1) blue, (1) orange.
- Shield—Mylar/aluminum tape shielding, applied with a nominal overlap of 20%, with the aluminum side in contact with the drain wire.
- Jacket—Polyvinyl chloride, having an average wall thickness of 1.14 mm (0.045 inch), conforming to IMSA Specification 19-1, and rated at 80 °C (176F).
- Electrical—dc resistance of each conductor, less characteristics than 11 ohms per 305 m (1,000 feet). Capacitance between each insulated wire and all other less than 157.5 pF/m (48 pF per foot).
- Finished outside diameter—Less than 7.6 mm (0.300 inch).