922-T-168 TRAFFIC SIGNAL MATERIALS AND EQUIPMENT

(Revised 09-15-11)

The Standard Specifications are revised as follows:

SECTION 922, DELETE LINES 1 THROUGH 1850.

SECTION 922, AFTER LINE 1850, INSERT AS FOLLOWS:

SECTION 922 – TRAFFIC SIGNAL MATERIALS

922.01 Description

All traffic signal materials and equipment shall be in accordance with the NEMA TS2-2003 Standards Publication, and be compatible with the Department's current inventory of signal equipment, unless specifically outlined in the following specification.

922.02 Traffic Signal Control Equipment

Models shall be selected from the Department's list of approved Traffic Signal and ITS Control Equipment, unless otherwise specified.

(a) Model Approval

Each model of controller assembly, CA, and all major units, as defined in NEMA TS2-2.1.1, will be tested and evaluated by the Department's Logistical Support Center, and approved prior to use. The CA, as defined by NEMA TS2-1.1.7, as being a complete electrical unit, shall include major units operational in a TS2 environment. Major units of the CA are defined as controller unit, CU; malfunction management unit, MMU; bus interface unit, BIU; cabinet power supply; load switches; vehicle detector equipment; cellular modems; radio modems, and flasher. The evaluation of a product will be considered when the Department receives the preliminary product evaluation submittal form. The Department will advise the manufacturer or vendor, of the date of delivery at which time a presentation of the product will be required accompanied by the product brochure, the operational manual containing procedures for all features incorporated in the CU's design, and the maintenance manual containing all schematics, pictorial parts layouts, components parts listings, and documented theory of operation. Certification in accordance with 922.02(d) shall also accompany the preliminary product evaluation form. If a product has TS2 communicative capabilities, then a data analysis interpretation offered in a decimal form expressing frames by an SDLC protocol analyzer shall accompany the initial documentation as well. When accuracy of documentation is validated, the evaluation period may commence. In addition, all computer system software applicable to a manufacturer's product shall work with the Department's current operating systems so that upgrades will not be needed to recognize the full potential of the product. Any product under evaluation that has an operational failure occurring during the bench test procedure will be rejected and returned to the submitter. The product will not be considered for future evaluation without a cover letter documenting failures encountered and changes to the design to correct the failures. A presentation by the manufacturer of the product in question and explanation of why the product failed will be required. Resubmittal of the original product will be expected for testing, evaluation, and approval. Furthermore, 2 more rejections of a product submitted for evaluation will be cause to deny approval of that model permanently.

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Continued failures indicative of a trend, repeated random malfunctions, or NEMA non-compliance of an approved product shall be cause to remove that model from the Department's list of approved Traffic Signal and ITS Control Equipment. If the manufacturer makes any changes to an approved model of major unit and/or controller cabinet terminal/facilities to correct a non-NEMA compliant or safety issue, the Department is to be notified immediately. The manufacturer will be required to correct all existing equipment purchased by the Department either directly, by contract, or through agreement prior to the change being incorporated at the manufacturer's production level.

A design change to an approved model of a CA or any major unit will require a submittal of documented changes. At the discretion of the Department, resubmission of the model for testing, evaluation, and approval may be required. The permanent addition or removal of component parts or wires, printed circuit board modifications, or revisions to memory or processor software, are examples of items that are considered to be design changes.

(b) Controller Assemblies or Major Units Furnished and Installed by the Contractor

A CA, as defined by NEMA TS2-1.1.7, shall be provided by the Contractor and shall be built to the specifications of the intersection design.

Each CA shall be supplied with 3 documentation packets. The documentation shall be provided in both paper hard copy and electronically as specified for each document. Each packet shall consist of:

1. *One complete set of wiring and schematic diagrams for all of the CA's panels, racks and wiring; the electronic document shall be Adobe (.pdf) and have a minimum of 1 indexed page for each paper sheet.*

2. *A parts list indicating contract number, vendor, category, manufacturer, model, serial number, software/firmware version as applicable, and inventory number of all major units incorporated in the CA; the electronic document shall be MS Excel (.xls) and the blank worksheet shall be obtained from the Department's Logistical Support Center.*

3. *An 11 by 17 in. intersection design plan; the electronic document shall be Adobe (.pdf).*

4. *A completed Department approved loop tagging table; the electronic document shall be MS Excel (.xls) and the blank worksheet shall be obtained from the Department's Logistical Support Center.*

5. *Packet number 2 shall also include a paper hard copy and an indexed and searchable electronic pdf format file of the instructional programming manual identical in nature to that approved for use*

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during the evaluation of each product and shall include a TS2 type 2 to TS2 type 1 adapter harness.

All electronic documents shall be saved to CD (compact disk, CD-R or CD-RW) in the specified format for each document. Each packet shall be labeled with the name of the intersection, the contract number, the commission number and the date of installation. Packet destinations shall be as per 805.08.

A 60-day burn-in period of traffic control equipment shall be required prior to acceptance of the contract. The Contractor shall be responsible for all costs associated with vendor or manufacturer warranty service until acceptance of the contract, or acceptance of that portion of the contract where the traffic control equipment is installed.

(c) Warranty

A 5-year manufacturer's or vendor's warranty shall be provided for all major units operating in a TS2 environment. Light emitting diode, LED, signal indications shall have a 5-year manufacturer's or vendor's warranty. Video detection equipment shall have a 10-year manufacturer's or vendor's warranty period on processors, integrated camera/processor units, rack mount cards, hubs, minihubs and camera interface panels. CCD video cameras shall have a 5-year manufacturer's or vendor's warranty. Load switches and flashers shall have a 2-year manufacturer's or vendor's warranty. Warranty periods shall commence from the date of field placement of the device or on the date of signal turn-on as shown on the IC 636A form if purchased through a contracting agent.

(d) Certification of NEMA TS2 Traffic Control Equipment

The following certifications shall be furnished.

1. Certification of a Production Run Model

A certification representing each model of approved major unit of a CA shall be on file with the Department. A certification of a production run model for a CU will be valid for a maximum period of 5 years from the date of approval or unless a significant change is made in the CU. If a significant change is made, a new certification shall be submitted. A significant change shall be the addition or deletion of any function or feature in the control unit, or any other change as defined in 922.02(a) to the circuitry in the product.

2. Certification of Environmental Testing

A certification shall be furnished with each major unit approval request indicating it has been tested and is in accordance with the tests from NEMA TS2-2. The certification shall specify the model and serial number of the product being tested. A complete log of each test shall be provided to the Department and will be maintained by the Department. The log shall show which, if any, controller component failed during the test, when it failed, and what steps were taken to repair the controller. The log shall include the date of testing, name and title of person conducting the tests, a record of conditions throughout the tests, and a temperature and humidity verses time chart. The maximum report interval of any chart shall be 24 h. The chart shall be from a recording machine used to monitor the status of the environmental chamber during testing.

ARCHIVED

(e) NEMA TS2 Fully Actuated Solid State Controller Unit, CU

The following requirements are the minimum for the design and operation of a 16 channel fully actuated solid state CU. The NEMA TS2 configuration will consist of 2 types of CU's, type A1 and type A2, as defined in NEMA TS2-3.2.

The CU shall be in accordance with NEMA TS2 Standards, all provisions contained herein, and the Department's specifications. Manufacturer specific enhancements are acceptable; however, no function or device shall preclude the interchangeability of a CU with another CU of like NEMA specification within a controller assembly.

1. General Requirements

The CU shall be microprocessor based and both versions shall contain a 3-port configuration and shall operate in the NEMA TS2 type A1 environment.

The CU shall include provisions for time-of-day programming. The CU shall be capable of a minimum of 50 programmed events and be in accordance with NEMA TS2-3.8.

A removable nonvolatile EEPROM module shall be utilized in each CU to maintain all programmed data. A real-time clock shall be battery-backed and active during a power outage so as to provide complete time keeping functions and leap year corrections. A switch or other means shall be provided to turn off or disconnect battery power during storage. This shall be accomplished without physical removal of the battery. Batteries within the CU shall be turned off or disconnected during storage and shipment.

Programming and maintenance manuals for approved CU's shall be identical in nature to that approved for use during the evaluation period of the CU. The Department shall be notified of any changes to the manuals.

Serial number and model numbers shall be permanently applied on or near the front of circuit boards of the CU and viewable without removing or disconnecting the board. Serial number and model number of the main frame shall be permanently applied externally on top or on the front panel.

2. CU Requirements

The requirements set forth herein refer to a type A1 and A2 CU. Where differences occur between types, it will be designated.

The CU shall have, as a minimum, the internal diagnostics defined by NEMA TS2-3.9.3.

The CU shall monitor and log the status of events as specified in NEMA TS2-3.9.3.1.5 in non-volatile memory and shall be selectable via program entry and be retrievable by the system computer via NEMA port 2 or 3. In addition, the CU shall have the ability to log an MMU fault as it occurs. A minimum of 16 entries shall be stored in

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non-volatile memory. When capacity is exceeded, the oldest entry will be replaced by the newest. Logged entries shall at minimum contain the date and time denoted in military style with minute resolution, description of the fault as it would appear on the MMU, and the status of each of the channel inputs at the time the fault occurred, clearly denoting the presence of activity on a channel.

The CU shall be capable of all inputs and outputs listed by controller type in NEMA TS2-3. Pedestrian timing shall be provided on all phases of a CU. Unless otherwise indicated on the plans, the CU, when delivered, shall be programmed to initialize in phase 2 and phase 6 green, however, the CU shall be keyboard programmable to permit initialization in any color and phase. Initialization shall occur after a recognized power interruption, upon MMU reset, or upon return from manual or time-of-day flash. The CU shall be programmable from a closed loop computer system, a laptop computer using the RS232 port, front panel programming, and by downloading from another like CU through the RS232 port.

Keystroke buttons shall be clearly marked as to function. All programming buttons and indicators pertinent to the operation of a phase shall be on the front of the CU and shall have programmable phase omitting and phase skipping capabilities.

The TS2 type A2 CU shall be in accordance with all applicable requirements for a type A2 CU as defined by NEMA TS2-3 and shall contain a full compliment of connectors.

3. Internal Modules

All plug-in modules shall be equipped for easy removal or installation without the use of tools and shall be readily accessible for maintenance. All internal module plugs and edge card plugs shall have the corresponding pin connector position labeled with the first and last numbers or the first and last letters.

4. CU Enclosure

The enclosure shall be of adequate strength to protect the components during normal handling. The keypad, liquid crystal display and all interface connectors required for the operation and standard field adjustments shall be mounted on the front panel. Fusing shall be on the front panel of the CU and shall provide protection from internal or external overload.

The front panel of the controller shall be fastened to the frame such that no special tools shall be required to remove or replace printed circuit board modules nor to gain access through the front panel. All hinges shall have stainless steel pins.

5. Firmware and Software Revisions

The Department's Logistical Support Center shall be notified each time an update or revision of the firmware or software is released, explain the changes, and the benefits of the change. The Department will determine if and to what extent a revision is to be placed into field operation and may fully re-evaluate the CU with the revision.

ARCHIVED

(f) NEMA TS2 Cabinet, Auxiliary Equipment, and Terminal and Facilities, TF, Requirements

These standards define the minimum requirements for a TS2 type A1 cabinet, both inside and out. The performance and construction of the cabinet shall be in accordance with the applicable requirements of NEMA TS2 sections 4, 5, 6, and 7. The serial number and model number of the auxiliary equipment shall be permanently applied externally on or near the front of the product. Programming and maintenance manuals for approved products shall be identical in nature to that approved for use during the evaluation period of the product. The Department shall be notified of all changes to the documentation. Manufacturer specific enhancements are acceptable, however no function or device shall preclude the interchangeability of an auxiliary product with another product of like NEMA specification within a controller assembly.

1. Controller Cabinet Requirements

The NEMA TS2 type A1 controller cabinet shall be in accordance with the following requirements.

a. General

The cabinet and the shelves shall be fabricated of aluminum. The cabinet shall be 1/8 in. (3.18 mm) minimum thickness sheet aluminum or 1/4 in. (6.35 mm) minimum thickness die-cast aluminum. The cabinet exterior and interior including shelves shall have a sandblasted, roughened, or chemically etched finish that reduces gloss, reflection, and glare.

The main cabinet door shall use a Corbin lock No. 2 and each cabinet shall be furnished with 2 No. 2 keys. The lock shall open in a counterclockwise motion only. The door shall be capable of being opened and stopped in at least the following 2 ranges of degree opening as measured from the face of the cabinet door on the hinged side: 80 to 100°, and 170 to 190°. The door shall be hinged on the right side of the cabinet. The main door and the police panel door shall close against a weatherproof and dustproof gasket seal, which shall be permanently bonded to the cabinet. A standard police panel key shall be provided with each cabinet.

A rain channel shall be incorporated into the design of the main door panel to prevent liquids from entering the enclosure. A 1 1/2 in. (38 mm) deep drawer shall be provided in the cabinet, mounted directly beneath the controller support shelf. The drawer shall have a hinged top cover and shall be capable of accommodating 1 complete set of cabinet prints and manuals. This drawer shall support 50 lb (23 kg) in weight when fully extended. The drawer shall open and close smoothly. Drawer dimensions shall make maximum use of available depth offered by the controller shelf and be a minimum of 24 in. (610 mm) wide.

b. Switches, Auxiliary, and Environmental Feature Requirements

The cabinet shall have a police door and a police control panel within the main door. The police panel shall have 2 different switches, 1 switch for field indication cutoff and 1 switch to transfer between automatic signal control and flashing operation. The switches shall be protected from water when the cabinet door is open.

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A test switch panel shall be mounted on the inside of the main door. The test switch panel shall include, as a minimum, the following switches. An auto/flash switch shall be installed so that when in the flash position, power shall be maintained to the controller and the intersection shall be placed in flash. A stop time switch shall be installed so that when in the 'On' position the controller shall be stop-timed in the current interval. A controller equipment power On/Off switch shall be installed which shall control AC power to the CU, MMU, and cabinet power supply. All switches mounted on the switch panel on the inside of the main door shall have in place a mechanism to prevent accidental activation of the switch. "Locking bat" type switches or side switch guards are acceptable. Switch guards, if used, shall be in place for each switch, shall be made of the same material as the cabinet, and shall permit the operation of the switch without the use of tools.

All switch functions shall be permanently and clearly labeled. Hand written labeling will not be permitted.

The cabinet shall include all required wiring, connectors and adapters to provide full compatibility and interchangeability with either a TS2 type A1 or type A2 controller.

c. Receptacle

The cabinet shall contain 1 duplex convenience outlet and a lamp receptacle that is actuated and turns on when the door is open and goes off upon closing of the door and an internal On/Off switch which can override the preceding. The convenience outlet shall be duplex, 3-prong, NEMA type 5-15R grounding outlet in accordance with NEMA WD-6, with ground-fault circuit interruption as defined by the National Electric Code. These units shall be protected with a 15-ampere cartridge fuse wired ahead of the multi-breakers.

Master cabinets shall have an additional duplex, 3-prong, NEMA type 5-15R grounding outlet. This outlet shall be powered by the 10-ampere circuit breaker and through a separate power interrupt switch providing separate control of the master CU power supply.

d. Fan and Filter

The cabinet shall contain a thermostatically controlled ventilating fan and a vent with a commercially classified uniform 1 in. (25 mm) thick filter. The thermostat shall be manually adjustable from 90 to 115°F (33 to 45°C). The fan shall be mounted internally at the top and toward the front of the cabinet to exhaust out the front top lip of the cabinet. The fan shall be rated at a minimum of 100 cu ft (3 m^3) per minute as designated by NEMA TS2-7.9.1. The thermostat shall be located within 6 in. (150 mm) of the fan.

The filter size will be according to the provisions for the type of cabinet as stated in NEMA TS2-7.9.2.3 and shall be a replaceable pleated air filter with a minimum efficiency reporting value, MERV, rating of 5 or higher as defined by the ASHRAE 52.2-1999 specification. The cabinet ventilation shall be in accordance with NEMA TS2-7.9.

Each inductive device, including the fan, shall have a separate power surge protection.

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2. Load Switch and Flasher Requirements

The cabinet shall contain a jack mounted type 3 solid state non-repairable flasher in accordance with NEMA TS2-6.3 electrical and physical dimensions.

The pedestrian load switch and the signal load switch shall be an approved unit meeting all electrical and physical dimension requirements in accordance with NEMA TS2-6. The load switch shall not use a printed circuit board to transmit the 115V AC line input or signal buss output. Each load switch shall offer 3 indicators, 1 for each circuit indicating the status of the input to the load switch.

The load switch signal outputs shall be brought to a separate terminal strip for hook-up of the signal displays. Load switches inputs shall be capable of being programmed for flash, overlap, vehicular, or pedestrian phases with the use of a standard slotted or phillips screwdriver via the cabinet terminal strip. The load switch input programming of the TS2 type A1 CU shall be accomplished through front panel data entry of a TS2 type A1 or a TS2 type A2 CU.

3. Terminal and Facilities Requirements

a. General Requirements

The TF layout shall be in accordance with NEMA TS2-5.2.7. The cabinet shall contain a main TF panel complying with NEMA TS2- 5 standards. The model number of the main panel shall be permanently applied to the front of the panel, where it is easily readable, without removing or disconnecting the panel. Each controller input and output circuit shall terminate on the main TF panel or on a supplementary panel. The phase arrangement of the controller shall coincide with the channel arrangement of the load switches and MMU. All outputs on channels 9 through 12 field connections shall have a 1μF capacitor placed at each output terminal on the front of the TF panel. All TFs within the cabinet shall be readily accessible for field connection without removing the controller or associated equipment and for maintenance in the cabinet. All stranded wiring shall be tinned. A 24 volt relay shall be used on the TF to remove 24V DC from the common side of the load switches, effectively taking the mercury relay out of the circuit when the signal is put in mechanical flash. The TF panel shall be hinged at the bottom and capable of swinging down, to allow accessibility of the wiring and terminals at the rear of the panel. The backpanel shall be attached to the cabinet such that access to the backside of the backpanel, for maintenance purposes, shall be accomplished without the use of special tools or removal of auxiliary panels, shelving, or other cabinet appurtenances. A bracket extending at least half the length of the NEMA load switch shall support all load switches.

Terminals shall be consecutively numbered on both sides of the TF panel and shall be in compliance with the appropriate schematic diagrams. All positions for load switches, flasher, and mechanical relays shall have reference designators on both sides of the TF panel. All nomenclature shall be on or adjacent to the component or terminal. All nomenclature shall be machine produced and not handwritten. Cabinet prints shall identify the function of each terminal position.

ARCHIVED

CU and MMU harness cables shall be of sufficient length to allow units to be placed on either shelf or on top of the cabinet while remaining in operational mode. RS485 port 1 communications cable shall also be of sufficient length to allow any port 1 cable to be utilized with any TS2 unit within the CA. The RS485 harness shall be constructed of a high quality shielded communications cable. The TF panel shall contain a resistor/capacitor network circuit which will provide an external restart pulse to initiate the startup sequence upon initialization from flash.

Remote flashing shall be provided for all signal circuits. Unless otherwise indicated on the plans, phases 2 and 6 shall be wired to flash yellow. All other phases shall be wired to flash red. Flashing for signal circuits shall be activated on 1 circuit for odd numbered phases and on the other circuit for even numbered phases.

b. Power Panel Requirements

A transparent plexiglass cover shall be provided over the CA power supply panel. The cover shall leave the switches on the breakers exposed as well as leave access to terminals at the bottom of the panel for wiring purposes. No terminals on the power panel shall have silicon protectant on them in lieu of the plexiglass cover. The panel shall contain a multi-breaker with one 10 A circuit breaker to provide overload protection to the CU, MMU, BIU, +12/24V DC cabinet power supply, and detection devices. It shall also contain 1 main circuit breaker of 35 or 40 A, to provide over-load protection to the signal and flash buss load. All breakers shall have line and load terminals clearly labeled. The signal bus shall be connected to the incoming AC line through a mercury contact switch or a solid state control device functionally equivalent to the NEMA 5.4.2.3 specified contact switch. The terminals for AC + and − input to the cabinet shall be capable of accepting a No. 6 wire.

With the CA 10 A and main 35 or 40 A circuit breakers 'Off' (tripped), all units inside the cabinet and the intersection display shall be 'Off'. With the 10 A breaker 'On' and main 35 or 40 A circuit breaker 'Off', the signal output shall be 'Off' and the major units within the cabinet shall function. With the 10 A breaker 'Off' and main 35 or 40 A circuit breaker 'On', the intersection shall be in flash mode and all units within the cabinet will be 'Off'.

The cabinet shall contain a 50 kA 8 x 20 µs surge suppressor. The surge suppressor shall be a 120V AC, 15 A, minimum 2-stage parallel/series type device and protect lines: line-neutral, line-ground and neutral-ground, have a maximum continuous operating voltage of 140V AC, maximum clamp voltage of 350 volts and device status indicators of green/good and red/failed. The device shall plug into a NEMA 12 position terminal base wired before and in parallel with the 35 or 40 A main signal buss circuit breaker and in series with the 10 A circuit breaker for the solid state equipment and provide for a tool-free replacement of the device. There shall be a minimum of 2 electrical receptacles on the equipment side of the device for future auxiliary equipment. The surge suppressor shall operate between -30 to 165°F (-34 to 74°C). The dimensions of the unit shall not exceed 4 1/2 in. (114 mm) wide by 7 in. (178 mm) long by 3 1/2 in. (89 mm) deep.

ARCHIVED

All equipment capable of operating at 12 or 24V DC typically powered by an individual receptacle type power supply shall have a power cable permanently wired into the cabinet and the device shall be powered by the cabinet TS2 power supply

4. MMU Requirements

The cabinet shall contain a MMU and shall be in accordance with the standards of NEMA TS2- 4. The MMU shall be wired to monitor each load switch output.

5. BIU Requirements

All BIU's shall be in accordance with NEMA TS2 1998, Section 8. Edge mounted printed circuit boards and rack cards shall not have jumper wire modifications unless the jumper wires are permanently bonded to the PCB over its entire length. BIU's shall be supplied with each cabinet to allow for maximum phase and function utilization for which the cabinet is designed.

6. Loop Amplifier Units and Rack Requirements

a. General

All loop amplifier units shall be in accordance with NEMA TS2-6 and shall follow type C, 2 channel with delay and extend, as stated in NEMA TS2-6.5.2.2.1. All amplifiers shall be selected from the Department's List of Approved or Prequalified materials for each type of amplifier. In addition, loop amplifiers shall have an LCD display or a RS232 serial data connection and software interface capable of displaying loop status including but not limited to operating frequency and -ΔL/L, diagnostics, and all amplifier settings and operating parameters. Edge mounted printed circuit boards and rack cards shall not have jumper wire modifications unless the jumper wires are permanently bonded to the PCB over its entire length.

All detection components including amplifiers, racks, auxiliary BIU, interface panels, lead-ins, and all connecting harnesses shall provide 1 count output channel per lane of each approach within project limits.

All loop amplifiers designated for counting shall meet all requirements as above and shall additionally transmit channel 1 and 2 count pulses on the edge connection assigned to channels 3 and 4 respectively. Counting amplifiers shall be configured with count outputs mapped to and recorded in the CU detector logs. The status output of each active counting channel (3 and/or 4) shall be set to logic ground by software configuration within the amplifier or externally by use of jumper card in the adjacent slot.

An auxiliary BIU panel may be used strictly for count outputs (channels 3 and/or 4 only); in this configuration, the status outputs for those count output channels may be wired to logic ground on the BIU panel. The status outputs for all standard output channels shall provide accurate status data at all times. All detector input data to the CU shall remain accurate at all times.

All size 5 (M) and size 6 (P-1) cabinets shall incorporate a 16 channel detector rack, configuration No. 2, as per NEMA TS2-5.3.4 and shall allow operation of a 2

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channel detector in each slot and the capability of operation of a 2 channel counting amplifier in each even-numbered slot with the respective count outputs in each odd numbered slot. The number of detector racks provided shall be determined by the loop tagging table. All size 3 (G) cabinets shall incorporate an 8 channel detector rack, configuration No. 1, as per NEMA TS2-5.3.4.

All detector loop panels and detector racks shall be labeled according to the loop tagging table and as follows.

All detection shall be labeled in such a way that the numbering for any loop is consistent throughout the cabinet; the loop terminated as Loop or Detector 17 shall be Detector Channel 17 in the detector rack and Detector Input 17 to the controller.

b. Loop Termination Panel

Each loop lead-in panel shall be labeled on the upper left corner with the loop numbers that are terminated on that panel as follows: (1-16), (17-32), (33-48), (49-64). Each loop termination point shall be labeled with the corresponding loop number. Example: For panel 17-32: loops terminated on this panel will start with 17 and end with 32.

c. Detector Rack

Each detector rack shall be labeled at the bottom of the rack with a continuous label. The label shall be 1 in. wide, thermal printed black on clear, white or matte polyester tape with permanent adhesive, water, chemical and scratch resistant printed with 4 lines of Arial, size 10 font. Below the BIU shall be the BIU number and detector channel numbers that are contained within the rack as follows: (1-16), (17-32), (33-48), (49-64). This area shall also contain the intersection for diamond interchanges controlled from 1 cabinet. Each slot shall be labeled below the module with the corresponding loop tag information; the count output number portion of the information shall be under the first part of the tag information. For each 2-channel module, channel 2's label shall be below channel 1's label.

7. Cabinet Power Supply Requirements

The TS2 cabinet power supply shall adhere to the guidelines of NEMA TS2-5.3.5. The power supply shall be encased on all sides so that no circuitry is exposed to the user.

8. Cellular Modems

a. Service Provider

All data, power and antenna cables and all supplemental hardware shall be provided. The modem shall be compatible with the Department's current cellular carrier/provider (Verizon as of 07/07) and the traffic control device and closed loop communications software that it is supplied for.

b. Modem Hardware

Cell modems shall be Airlink Raven CDMA C3211 or similar modem with the following specifications: The cellular modem shall be capable operating in CDMA dual mode (both 800 MHz cellular and 1.9 GHz PCS bands), supporting both circuit switched

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and 1XRTT packet switched services. The operating voltage range shall include 12V and 24V DC and shall draw less than 250 mA while transmitting and receiving at 12V DC. The modem shall have LED indications for power, signal status/strength, and TX/ RX either separately or combined. The serial interface shall be RS232 with a DB9 (male or female) connector.

c. Modem Antenna

The RF antenna connection shall be a 50 Ω TNC connector. The antenna shall be a low profile, puck style, flat mount dual band, (800 and 1900 MHz) with low loss RG58 cable and TNC connector.

d. Modem Software

The modem configuration shall be editable and viewable with MS-Windows provided software or with proprietary software that is included and designed to run on a MS-Windows operating system. The software shall auto-detect connection parameters and display settings when connected.

e. Installation

Service and activation shall be requested and/or confirmed for each cellular device to be installed prior to installation. The ESN and 10-digit phone number shall be clearly labeled on the exterior of the modem. The cellular modem shall be installed, configured and tested to allow data communication from the central closed loop software to the field master and subsequent secondary controllers, or directly to a secondary controller per the design. All data, power and antenna cables and all supplemental mounting hardware shall be installed. The modem shall be powered by the cabinet power supply from a terminal location on the cabinet back panel or the power distribution panel. A low profile antenna shall be mounted externally and the mounting location includes a watertight seal. The antenna shall have no more than 3 ft excess RG58 cable in the cabinet.

9. Radio Interconnect Using Spread Spectrum Radio Modems

Spread spectrum radio modems for communications between local controllers and the system master controller shall be on the Department's list of approved Traffic Signal and ITS Control Equipment and shall be in accordance with ASTM E 2158, and as set out herein.

The spread spectrum radio modems shall provide all the needed features to communicate with NEMA TS2 type 1 and type 2 traffic signal controllers in a coordinated closed loop system. The radio modems shall be software configurable to be either a master, repeater, repeater/slave, or slave radio. The radio modem shall require no user license from the FCC; operate in the 900 MHz range, and be of frequency hopping spread spectrum, FHSS, technology; support data rates from 1.2 kbps to 115.2 kbps asynchronous; have a receiver sensitivity of at least -110 dBm; have a minimum RF output level of 1 watt; have a minimum of 50 user-selectable hopping patterns and a minimum of 50 RF non-overlapping channels allowing multiple systems to operate in the same line-of-sight path; operate as a transparent RS232, or RS422/RS485, or FSK 1200 baud types of links for use in a point-to-multipoint system; have an external SMA female type or N-female RP-TNC female antenna connector; and be supplied with power supply

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for 120V AC operation. The modems shall be rack or shelf mounted in standard NEMA TS2 type 1 or type 2 cabinets. The modems shall have an operation temperature of -40 to 176°F (-40 to 80°C), have a maximum current draw of 500 mA for the transmission of 1 watt of RF output power, while operating on 12V DC. Lighting and transient protection on all data lines and antenna connector, and AC/DC power distribution, shall be provided with the system.

The spread spectrum radio modems must include a Windows based, configuration software package, which will include a graphical user interface, GUI, allowing for ease of programming, through pre-written drivers for all Department approved traffic controllers and have the ability to automatically determine, and connect, at their radios baud, stop and parity settings. The configuration software must allow for signal level, RSSI, data integrity, message polling, and spectral analysis testing. The software must also permit all the radios within a system to be configured from a single location. All radio equipment and cables shall be delivered preconfigured and ready for field operation.

The manufacturer, or vendor, shall supply with each modem, the operational manual containing procedures for all features incorporated in the modem.

a. Transient Protection

Transient protection shall be installed between the radio modem and the field antenna. The transient protection shall be flange mounted in the cabinet and have a minimum transient current of 40 kA for 8 x 20 µs pulse, an insertion loss or $\leq$ 0.1 dB, have an operating frequency in the 900 MHz range, allow throughput energy to be $\leq$ 220 µJ for 6 kV /3 kA @ 8/20 µs waveform, have throughput voltage $\leq$ 144 Vpk, and turn-on voltage shall be ± 600 volts. The unit impedance shall be 50 Ω.

b. Antennas

The antenna for the radio modem at the system master/local controllers shall be capable of providing a transmission range adequate for communication with all radio modems or repeaters in the system and must be configured as a single omni, single-yagi, or dual-yagi (2 single-yagi antennas on differing alignments) for each radio as described below.

(1) Omni Antennas

All omni antennas shall be capable of producing between 6 dBd and 10 dBd (8.15 dBi and 12.15 dBi) of gain while operating in, and covering the entire 902-930 MHz frequency range. The voltage standing wave ratio, VSWR, of the omni antenna shall be 1.5:1 or less when the antenna coax feed impedance is 50 Ω. Omni antennas shall be fabricated of fiberglass, brass, copper, and/or aluminum and shall be rated for wind velocities of at least 100 mph. The minimum length of the omni antenna shall be 60 in. and it shall be designed and fabricated with a fiberglass radome with a minimum diameter of 2 in. to prevent ice from collecting directly on the driven element. All omni antennas shall have a cableless N-female connector directly affixed and sealed to the antenna body. All hardware and fastenings devices shall be fabricated from stainless steel.

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(2) Yagi / Dual-Yagi Antennas

All yagi antennas shall be capable of producing between 10 dBd and 13 dBd (12.15 dBi and 15.15 dBi) of gain while operating in, and covering the entire 902-930 MHz frequency range. The voltage standing wave ratio,VSWR, of the omni antenna shall be 1.5:1 or less when the antenna coax feed impedance is 50 Ω. The front to back ratio must be at least 20 dB for each yagi antenna. Yagi-directional antennas shall be fabricated of either anodized or powder coated 6061/T6 aluminum rod and seamless drawn pipe and shall be rated for wind velocities of at least 100 mph. All yagi antennas shall have a cableless N-female connector directly affixed and sealed to the antenna body. The yagi antenna shall be designed and fabricated so that polarization changes (vertical to horizontal) can be made on the antenna mount without adjusting the mast. Single yagis shall be connected by a low loss N-female "T" splitter/coupler and LMR-400 cable to form dual-yagi systems. All hardware and fastenings devices shall be fabricated from stainless steel.

c. Antennas Cable and Hardware

The coaxial cable used as the transient protection to antenna lead shall have no greater than 3.8 dB loss per 100 ft of length and shall be LMR-400.

All LMR-400 connections are to be stripped, deburred, and crimped using the ST-400-EZ LMR-400 stripping tool, DBT-01 LMR-400 deburring tool, and a 0.429 in. hex crimp die for solderless LMR-400 connections respectively. All connections shall be completely sealed by heat shrinking double walled, adhesive lined shrink tubing for weather proofing and strain relief.

Cables shall be included to interface the radio equipment to the transient protection. The antenna mounting hardware shall securely attach the antenna to the strain pole/cantilever arm. The coaxial cable fitting on the antenna shall not support the weight of the coaxial cable run to the base of the strain pole/cantilever arm.

d. Data Cables

Cables shall be included to interface the radio equipment to the system master, co-located secondary controller, remote secondary controllers and any communication interface panels as needed. Cables shall include strain relief back shells designed to mate and lock with the telemetry connector on the system master and local controllers. All radio equipment and cables shall be delivered preconfigured and ready for field operation.

All miscellaneous equipment necessary to complete the installation shall be as specified by the radio modem manufacturer.

(g) Cabinets

1. Size 3 (G) Cabinet

The size 3 (G) cabinet shall be pedestal-mounted or pole-mounted. As per NEMA TS2-5.3, the TS2 type 1 G cabinet, at minimum, shall house an 8-load switch bay (configuration 2) terminal and facilities panel and shall have 1 adjustable shelf located 12 in. (305 mm) below the top of the cabinet. The bottom of the cabinet shall be

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reinforced to ensure a secure pedestal mounting. The G cabinet shall have dimensions of 25 in. (635 mm) wide, 38 in. (965 mm) high, 18 in. (460 mm) deep with a tolerance of ± 4 in. (100 mm) in any or all dimensions.

A cabinet slipfitter shall be used to attach the cabinet to the pedestal. The slipfitter shall fit a 4 1/2 in. (114 mm) outside diameter pipe and shall have a minimum of 3 set screws equally spaced around the slipfitter.

A vent of adequate size shall be provided. The size of the vent and the filter requirements shall be in accordance with the manufacturer's recommendations.

2. Size 5 (M) Cabinet

As per NEMA TS2-5.3, the TS2 type1 (M) cabinet, as a minimum, shall house at minimum an 8-load switch bay (configuration 2) terminal and facilities panel and shall have 2 adjustable shelves with the first shelf located 15 in. (380 mm) below the top of the cabinet and the second located 7 in. (180 mm) below the first shelf.

The M cabinet shall be ground-mounted on a concrete foundation at locations and dimensions as shown on the plans.

The M cabinet shall have dimensions of 30 in. (760 mm) wide, 48 in. (1,220 mm) high, and 16 in. (410 mm) deep with a tolerance of ± 2 in. (± 50 mm) in any or all dimensions.

Anchor bolts shall be steel in accordance with ASTM A 36 (A 36M). Diameter of the bolt shall be 1/2 in. (13 mm) or 5/8 in. (16 mm) and the minimum length shall be 15 in. (380 mm) plus a 3 in. (75 mm) right angle hook on the unthreaded end.

The top 6 in. (150 mm) of the bolt shall be threaded with 13 NC threads on 1/2 in. (13 mm) bolts and 11 NC threads on 5/8 in. (16 mm) bolts. The hexagon nut, the flat washer, and the threaded end of the bolt shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C.

3. Size 6 (P-1) Cabinet

The size 6 (P-1) cabinet shall be ground mounted on a concrete foundation at locations and dimensions as shown on the plans with anchor bolts in accordance with 922.02(g)2. As per NEMA TS2-5.3, the TS2 type 1 P-1 cabinet, at minimum, shall house a 16-load switch bay (configuration 3) terminal and facilities panel and shall have 2 adjustable shelves with the first shelf located 20 in. (510 mm) below the top of the cabinet and the second located 7 in. (178 mm) below the first shelf a minimum of 30 in. (762 mm) above the bottom of the cabinet, the second located 12 in. (305 mm) above the first shelf.

The cabinet shall be 44 in. (1,120 mm) wide, 52 in. (1,320 mm) high, and 24 in. (610 mm) deep with a tolerance of ± 3 in. (± 75 mm) in any or all dimensions. Maximum exterior dimensions shall be 47 in. (1,195 mm) wide, 63 in. (1,600 mm) high, and 34 in. (860 mm) deep.

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4. Size 7 (R) Cabinet

The size 7 (R) cabinet shall be ground mounted on a concrete foundation at locations and dimensions as shown on the plans with anchor bolts in accordance with 922.02(g)2. As per NEMA TS2-5.3, the TS2 type 1 R cabinet, at minimum, shall house a 16-load switch bay (configuration 3) terminal and facilities panel and shall have 3 adjustable shelves with the first shelf located a minimum of 30 in. (762 mm) above the bottom of the cabinet, the second located 12 in. (305 mm) above the first shelf and the third located 8 in. above the second shelf. All shelves shall be adjusted so that the second shelf is located 63 in. ±3 in. (1,600 mm ±75 mm) above the top of the concrete footpad.

The cabinet shall be 44 in. (1,120 mm) wide, 72 in. (1,830 mm) high, and 24 in. (610 mm) deep with a tolerance of ± 3 in. (± 75 mm) in any or all dimensions. Maximum exterior dimensions shall be 47 in. (1,195 mm) wide, 83 in. (2,110 mm) high, and 34 in. (860 mm) deep.

5. Flasher- Two Circuit Alternating Flasher

Two circuit alternating flasher shall be solid state.

a. General

The solid state flasher shall periodically interrupt a source of alternating current line power. Solid state shall mean electrical circuits, the active components of which are semi-conductors, to the exclusion of electromechanical devices or tubes.

The flasher shall be a type 3 solid state flasher conforming to Section 8 of the NEMA Standards Publication TS1-1983. The flasher output circuit carrying the signal load shall consist of opto or photo isolated solid state power relays and shall be hard wired to the flasher connector.

Three schematic diagrams and 3 descriptive parts lists shall be furnished with each flasher.

Two circuit alternating flashers shall be plug-in design. The flasher design shall not permit the unit to be inserted improperly into the plug-in base. The flasher shall have heavy-duty plugs and jacks capable of handling the rated load current. The rate of flash shall be 50 to 60 flashes per minute.

The flasher shall operate between 95V and 135V AC 60 Hz. No degradation of performance shall be experienced in environmental changes from -20 to 165°F (-29 to 74°C) and 0 to 90% relative humidity.

b. Cabinet Requirements

The cabinet shall be weatherproof and fabricated from cast aluminum or aluminum sheeting with a minimum thickness of 1/8 in. (3.18 mm). The cabinet door shall be the entire front of the cabinet and shall be hinged on the right or left side of the cabinet. A Corbin No. 2 lock and 2 No. 2 keys shall be furnished. The lock shall be located near the center of the door on the side opposite the hinge.

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Minimum dimensions for the cabinet shall be 12 in. (305 mm) deep, 12 in. (305 mm) wide, and 12 in. (305 mm) high. The maximum dimensions shall be 18 in. (460 mm) deep, 15 in. (380 mm) wide, and 18 in. (460 mm) high.

The cabinet shall have 2 pole plates for stainless steel band mounting of the cabinet on a pole with a minimum diameter of 4 in. (100 mm) and a maximum diameter of 18 in. (460 mm). Two blank cover plates shall be provided. Two hub plates for 1 in. (25 mm) diameter conduit shall be provided with gaskets, 8 bolts at 4 bolts per plate, nuts, and washers for attaching the hub plates to the cabinet. The cabinet shall be drilled for the mounting of the pole plates or hub plates as shown on the plans.

It shall have a screened vent in the bottom with a minimum size of 1 3/4 sq in. (1,129 mm^2), and a minimum of 1 louvered and screened vent towards the top of the cabinet.

The panel in the cabinet shall be capable of being removed and reinstalled with simple hand tools. A 25 ampere radio interference filter and surge arrestor wired ahead of a 15 ampere circuit breaker shall be mounted on the panel. A terminal block capable of the following electrical connections shall be mounted on the panel.

Circuit 1 - for connection of field signals (flash circuit 1)
Circuit 2 - for connection of field signals (flash circuit 2)
Circuit 3 - for connection of field signals (field neutral)
AC plus - capable of accepting a No. 6 wire
AC minus - capable of accepting a No. 6 wire
Ground lug - capable of accepting a No. 6 wire

922.03 Signal Head Components

The components shall be in accordance with the Institute of Transportation Engineers for Adjustable Face Vehicular Traffic Control Signal Heads. All new traffic signal and flasher installations that include new indications shall be fitted with LED modules. All LED indications shall be selected from the Department's list of approved Traffic Signal and ITS Control Equipment.

(a) General

The signal faces shall be sectional in construction, requiring 1 section for each lens and furnished in the nominal size of 12 in. (305 mm). Each section of a face shall have a rectangular silhouette when viewed from the front or the rear.

(b) Housing, Door, and Visor

The top and bottom of each housing shall have an integral locking ring with 72 serrations to permit rotation of the signal housing in 5° increments. Hub openings in the top and bottom of the signal housing shall accommodate standard 1 1/2 in. (38 mm) bracket arms. The thickness of the hub at the top and bottom of the housing shall be a maximum of 1 in. (25 mm) and a minimum of 3/8 in. (10 mm). The 12 in. (305 mm) door shall have 2 simple locking devices. The door on the hinged side shall be attached with hinge pins. Each lens shall have the standard cap type visor. All screws, latching bolts, locking devices, and hinge pins shall be stainless steel.

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(c) LED Traffic Signal Indicator

All LED indicators shall be selected from the Department's list of approved Traffic Signal and ITS Control Equipment.

All LED indicators shall have a permanent indelible sticker affixed to the back of the module indicating month and year of initial installation.

All LED indicators provided shall be individually listed on a parts list indicating the contract number, vendor, category, manufacturer, model, serial number, and inventory number. Hard copy and electronic copies shall be provided. The electronic document shall be MS Excel (.xls) format and the blank worksheet shall be obtained from the Department's Logistical Support Center.

(d) Wiring

The field wiring leads shall be terminated with screw spade lug type connectors. The LED module wiring leads shall be terminated with 1/4 in. female type connectors for ease of connection to the terminal block.

(e) Section Coupling

Any method to connect 2 or more sections together may be used, if the following requirements are met:

1. *Two or more sections, when jointed together, shall maintain structural integrity when loaded in accordance with Institute of Transportation Engineers Standards.*

2. *The opening between joined sections shall accommodate two 1/2 in. (13 mm) cables.*

3. *The maximum length of bolts used to connect sections together shall be 4 in. (100 mm).*

Nuts, bolts, and lock washers shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and be in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C.

(f) Terminal Block

The yellow section of the 3-section or 2-section signal head and each 1-section signal head shall be equipped with a 5-position terminal block for termination of field wiring. Each section shall have provisions for two 5-position terminal blocks. Each terminal screw shall have a 1/4 in. corresponding spade tab. The terminal block shall have a minimum spacing between screw connections of 1/2 in. (13 mm). The height of the insulating ridge between screw connections shall be a minimum of 19/32 in. (15 mm) from the base of the terminal blocks.

(g) Material Requirements

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1. Polycarbonate Signal Head

The housing, door, and visor of the section shall be made of ultraviolet and heat stabilized polycarbonate. The color shall be permanently molded into the components except the inside surface of the visor shall be painted non-reflecting flat black. The color shall be yellow in accordance with 909.02(b).

2. Die-Cast Aluminum Signal Head

The housing, door, and visor of the section shall be made of a die-cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B 85. All surfaces of the housing, doors, and visor shall receive a prime coat of zinc chromate paint in accordance with 909.02(a) or shall be anodized with a chromate aluminum oxide coating process. The finish shall be highway yellow enamel, 2 coats, oven baked and in accordance with 909.02(b) except the inside surface of the visor shall be painted non-reflecting flat black.

(h) Certification

A material certification shall accompany each order certifying that a signal head from a normal production run within the past 12 months, passed the Institute of Transportation Engineers criteria for breaking strength and deflection. Deflection testing is not required in the certification for polycarbonate signal heads.

922.04 Pedestrian Signal Head

A pedestrian signal shall be 1 section and rectangular in shape. The dimensions of each side may vary from 18 to 19 in. (460 to 485 mm), including the visor and the hinges. The signal shall contain 2 figures with 2 different colored messages. The first figure shall transmit an upraised hand symbol message, and the second figure shall transmit a walking person symbol message. All new installations including new pedestrian indications shall use Light Emitting Diodes. All pedestrian LED indications shall be selected from the Department's list of approved Traffic Signal and ITS Control Equipment. The pedestrian signal shall be in accordance with the standard of the Institute of Transportation Engineers for Pedestrian Traffic Control Signal Indications.

(a) Housing, Door, and Visor

The housing shall be equipped with mounting device hardware, such as clamshell, and round openings at top and bottom for mounting with brackets made of iron pipe standard, to fit the 1 1/2 in. (38 mm) pipe. The openings shall have a common vertical centerline through the housing to permit 360° rotation after it is mounted. The openings shall have a serrated ring which permits locking of the housing in 5° increments throughout the entire 360° of rotation. The brackets or the clamshell shall serve as the electrical conduit for the pedestrian signal. The housing shall be made of die-cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B 85.

The door on the front of the housing may be hinged from any side. The door shall be gasketed to maintain a weather-tight enclosure when secured to the housing. The door and the visor shall be made of the same material as the housing or of polycarbonate. All materials shall be clean, smooth, and free from flaws, cracks, blowholes, or other imperfections.

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Each signal shall be provided with a visor.

The exterior of the housing shall be Federal yellow in color. The polycarbonate components shall be black in color, impregnated throughout. The metal components shall be painted with enamel in accordance with 909.02(c).

(b) Message

The upraised hand and walking person symbols shall each be a minimum of 11 in. (280 mm) in height. The width of the upraised hand symbol shall be a minimum of 7 in. (178 mm). The width of the walking person symbol shall be a minimum of 6 in. (150 mm). Message configuration, color, and size shall be in accordance with the standard of the Institute of Traffic Engineers for Pedestrian Traffic Control Signal Indications.

Each pedestrian signal shall be completely wired internally, and ready for connection of the field wiring. A suitable terminal block for connection of the internal wiring and the incoming field wires to the pedestrian signal head shall be provided in the signal housing.

The light source shall be designed and constructed so that if an electrical or mechanical failure occurs, the upraised hand and walking person symbols shall also remain dark.

922.05 Signal Bulbs

All new traffic signal and flasher installations that include new indications shall be fitted with LEDs in accordance with 922.03. The minimum design requirements for replacement light bulbs to be used in a traffic signal face shall be in accordance with the Institute of Transportation Engineers standard for traffic signal bulbs and as follows:

(a) Incandescent Bulbs

1. *Bulbs shall be 67 watt, 116 watt, or 150 watt for different kinds of indications, as specified below.*

INDICATION	*WATTAGE*
9 in. (230 mm) pedestrian	*67*
12 in. (305 mm) pedestrian	*116*
18 in. (455 mm) pedestrian	*116*
12 in. (305 mm) red	*150*
12 in. (305 mm) yellow and green	*116*
12 in. (305 mm) yellow and green arrows	*150*
Optically programmed heads	*150*

All bulbs shall have medium size, brass bases.

2. *Bulbs shall be designed for use in a horizontal position or a base-down position.*

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3. *The light center length shall be 2 7/16 in. (62 mm) for 67 watt bulbs and 3 in. (75 mm) for 116 watt and 150 watt bulbs.*

4. *The filament shall be C9 design with a minimum of 7 supports. The 2 voltage supply leads may be counted as 2 of the 7 supports.*

5. *The maximum, overall bulb length for 67 watt and 116 watt bulbs shall be 4 3/8 in. (110 mm) and for 150 watt bulbs shall be 4 3/4 in. (120 mm).*

6. *All bulbs shall be clear and shall be 130 volt.*

7. *The 150 watt bulb shall be P25 or A21 size and shape.*

8. *The 67 watt and 116 watt bulbs shall be A21 size and shape.*

9. *All bulbs shall have 6,000 h minimum burning life.*

922.06 Disconnect Hanger Junction Box

Traffic signal disconnect hanger junction boxes shall consist of a span hanger, a balance adjuster, a disconnect hanger clevis, and a housing with a hinged door with a positive latching device. The span hanger, balance adjuster, and all related hardware shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153. The housing shall be made of a die-cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B 85. The balance adjuster fitting shall be made of ferrous or non-ferrous metal. When made of ferrous metal it shall be galvanized in accordance with the requirements for the components and related hardware as set out above.

The disconnect hanger shall be designed so that the maximum allowable space or play between the span hanger and the eye-bolt of the balance adjuster and between the balance adjuster and the disconnect hanger clevis, at points where they are attached to each other by rivet pins or hex head bolts and nuts with lock washers, shall be 0.062 in. (1.6 mm). The span hanger bolt where the eye-bolt or the balance adjuster is attached shall be 5/8 in. (16 mm) diameter.

When serrated locking rings are not integrally cast in the components, the component and locking ring shall be designed so that when the locking ring is placed flush against the component, the component and locking ring shall not rotate or slide when torque is applied. The serrated components shall have 72 serrations to permit rotation of the disconnect hanger clevis, hub plate, or signal head in 5° increments. There shall be no thread in contact with a wearing surface. Locking rings shall have a minimum thickness of 3/16 in. (4.8 mm) and a maximum thickness of 1/4 in. (6.4 mm) from the base of the ring to the serration peaks. The inside diameter shall be 2 in. (50 mm) and the outside diameter shall be 2 7/8 in. (73 mm).

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The terminal block shall have an 18-point terminal block permanently engraved or etched with sequential numbers indicating the circuits. The terminal block shall not have a method of connection which allows a screw point to damage wires when the wires are securely connected. Each point of connection shall accommodate a minimum of four No. 14 gauge (2 mm) wires.

The disconnect hanger shall have 2 side entrance holes on opposite sides capable of receiving a 1 1/2 in. (38 mm) plastic or rubber insert to reduce water infiltration. It shall be capable of supporting signal faces in the ambient temperature range of -35 to 120°F (-37 to 49°C) without failure.

The balance adjuster shall have hex head bolts, lock washers, and nuts for securing the main body of the balance adjuster firmly onto and around the eye-bolt to prevent any twisting or turning of the head suspended below it. The span hanger shall have 2 J-bolts, lock washers, and hex head nuts adequate in size to securely fasten the hanger to a messenger cable up to 1/2 in. (13 mm) in diameter.

A type C certification in accordance with 916 shall be provided.

922.07 Free Swinging Signal Support Assemblies

(a) Clearance

The maximum allowable space or play between the hanger assembly and the eyebolt of the balance adjuster and between the balance adjuster and the weatherhead clevis, at points where they are attached to each other by rivet pins or hex head bolts and nuts with lock washers, shall be 0.062 in. (1.6 mm). No bushings or shims will be allowed in this assembly.

(b) Balance Adjuster

The balance adjuster shall consist of a hex head bolt, a lock washer, and nuts for securing the main body of the balance adjuster onto and around the threads of the eye-bolt to prevent any twisting or turning of the adjuster.

(c) Span Hanger

The span hanger, balance adjuster, weatherhead, and all related hardware shall be made of a non-corrosive metal or shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153. The weatherhead shall have a minimum of 2 1/2 in. (64 mm) of exposed threads. The weatherhead shall have 2 set screws to fasten the nipple to the weatherhead. If the weatherhead and threaded pipe has a slip-in connection, the locking device shall be a double nut assembly. If the weatherhead and threaded pipe has a screw-in connection, the locking device shall be a double set screw assembly.

The span hanger shall be furnished with 2 each of J-bolts, lock washers, and hex head nuts. The J-bolt shall be a minimum of 1/4 in. (6.4 mm) diameter and shall have sufficient threads to be able to secure the hanger to a 1/4 in. (6.4 mm) or to a 1/2 in. (13 mm) span cable.

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(d) Tether Bracket

The tether bracket shall attach to a 1/8 in. to 1/4 in. messenger cable and prevent the bottom of the head from moving side-to-side on the cable. Where backplates are installed on the signal heads; the tether bracket shall be of the proper length for the backplate so that the cable is mounted below the bottom of the backplate to avoid interference with head alignment and damage to the backplate.

(e) Pipe Arm Assemblies

The multiple pipe arm assembly shall consist of a span hanger assembly, a balance adjuster, a signal weatherhead, a 2, 3, or 4 way pipe arm, 1 1/2 in. (38 mm) pipe, a lower arm assembly, and all related hardware necessary for a complete assembly.

The 2, 3, or 4 way pipe arms shall have a minimum of 2 in. (50 mm) of exposed thread. Each arm of the pipe arm shall be furnished with two 72 serration locking rings. One locking ring shall have a 3 in. (75 mm) outside diameter and one locking ring shall have a 2 3/8 in. (60 mm) outside diameter.

ASSEMBLY	*MAXIMUM ALLOWABLE WEIGHT*
2 Way	*19 lbs (8.6 kg)*
3 Way	*25 lbs (11.3 kg)*
4 Way	*28 lbs (12.7 kg)*

922.08 Signal Cantilever Mount Signal Bracket

The bracket shall permit the following 4 adjustments:

(a) rotational adjustment about bracket axis;

(b) vertical adjustment;

(c) rotational adjustment about signal cantilever arm; and

(d) rotational adjustment right and left from vertical plane

The bracket shall be fastened to the supporting arm or structure with stainless steel bands. The bracket shall adjust to fit all sizes of round, octagonal, elliptical, or other shape structure without special tools or equipment.

The bracket shall attach to the signal by clamping the signal head both top and bottom and shall be designed to accommodate the specified signal configuration. Each bracket shall be complete with all necessary hardware to attach the traffic signal to the bracket and the bracket to the support.

All electrical wiring shall be concealed within the bracket, except that which runs from the bracket to the signal cantilever arm.

Upper and lower arms shall be cast from aluminum in accordance with ASTM B 26 (B 26M), alloy 713.0-T5 or 356.0-T6. The vertical support tube shall be extruded

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from aluminum in accordance with to ASTM B 241 (B 241M), alloy 6063-T6 or 6061-T6, and the strapping to attach the bracket to the arm shall be stainless steel. All steel or malleable iron parts shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153, class C.

922.09 Pedestal Poles and Cast Aluminum Pedestal Bases

The pedestal base used for mounting pedestrian signal heads or control cabinets shall be in accordance with 922.09(a). The length of the pedestal pole shall be as shown in the plans.

(a) Cast Aluminum Pedestal Base

A pedestal mounted G cabinet shall have a cast aluminum pedestal base. The cabinet and pedestal base shall be ground mounted on a concrete type A foundation at locations and dimensions as shown on the plans.

The cast aluminum base shall be made of aluminum in accordance with ASTM B 179, alloy ANSI 319.1 or 319.2, or in accordance with ASTM B 26 (B 26M), alloy ANSI 356.0-T6. The square base shall include an access door and anchor bolts with nuts and washers. The base shall be 13 3/8 in. (8,630 mm) square and 15 in. (380 mm) in height ± 1/4 in. (± 6 mm). The weight shall be 22 lbs ± 5% (10 ± 2.2 kg).

The base shall be designed to support a 150 lbs (68 kg) axial load and 11 sq ft (1 m^2) of signal head area rigidly mounted. For design purposes, the distance from the bottom of the base to the center of the signal head area is 18 ft (5.5 m). In addition to the dead load, the base shall be designed to withstand wind and ice loads on the specified signal head area and on all surfaces of the support, in accordance with the AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals. Wind speeds used for design shall be based on a 10 year mean recurrence interval and a wind drag coefficient of 1.2 or as shown in the plans. The base shall contain an access door, which is 8 by 8 1/4 in. ± 1/4 in. (200 by 210 mm ± 6 mm) with a stainless steel hex head bolt for attaching the door.

The base shall be attached to a foundation by 4 anchor bolts, with an anchor bolt circle of 12 3/4 in. (324 mm). Slotted lugs shall be integrally cast into the 4 corners of the base for attachment of the anchor bolts. The anchor bolts shall be steel in accordance to ASTM A 36 (A 36M). The diameter of the anchor bolt shall be 3/4 in. (19 mm) with a minimum length of 18 in. ± 1/2 in. (460 mm ± 13 mm), plus 2 1/2 to 3 in. (64 to 75 mm) right angle hook on the unthreaded end. The top 4 in. (100 mm) of the bolt shall be threaded with 10 NC threads. The threads, plus 3 in. (75 mm), shall be coated after fabrication in accordance with ASTM A 153 or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C. Each anchor bolt shall be provided with 2 hex head nuts in accordance with ASTM A 325 (A 325M) and 3 washers. Two of the washers shall have a minimum 2 in. (50 mm) and maximum 2 1/8 in. (54 mm) outside diameter and be in accordance to ANSI B 27, type B regular series and one shall be a nominal 3/4 in. (19 mm) series W washer, in accordance with ASTM F 436 (F 436M).

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The cast aluminum pedestal base shall be in accordance with the dimensions and requirements shown in the plans. The casting shall be true to pattern in form and dimensions; free from pouring faults, sponginess, cracks, and blowholes; and free from other defects in positions affecting the strength and value of the intended use for the casting. The base shall not have sharp unfilleted angles or corners. The surface shall have a workmanlike finish.

The door and bolt for the door shall be interchangeable on cast bases from the same manufacturer.

(b) Pedestal Pole

The top of the base shall accommodate a pole having a 4 1/2 in. (114 mm) outside diameter. The threads inside the top of the base shall be 4 in. (100 mm) national standard pipe threads. The pole shall be either a steel pedestal pole or an aluminum pedestal pole.

A steel pedestal pole shall be a seamless schedule 40 carbon steel pipe in accordance with ASTM A 53, grade B. The pole shall have an outside diameter of 4 1/2 in. (114 mm). The pole shall weigh approximately 10.8 lbs/ft (16 kg/m). The length of the pole shall be as shown on the plans. The pole shall have full depth national standard pipe threads on one end of the pole. The length of threads shall be 2 1/2 in. (64 mm). The pole shall be galvanized, after threading, in accordance with ASTM A 123. The threads shall be cleaned of all excess galvanizing and protected by a suitable shield.

An aluminum pedestal pole shall be in accordance with ASTM B 241 (B 241M) for seamless aluminum alloy, schedule 40, 6061-T6. The outside diameter of the pole shall be 4 1/2 in. (114 mm). The length of the pole shall be as shown on the plans. The pole shall weigh approximately 3.7 lbs/ft (5.5 kg/m). The pole shall have full depth national standard pipe threads on one end of the pole. The length of threads shall be 2 1/2 in. (64 mm) and protected by a suitable shield. The pole shall have a spun finish.

(c) Pole Cap

A pole cap shall be supplied for the top of the pole if the pole is used for the mounting of pedestrian signal faces or side mounted signal control cabinets. The pole cap shall be either a cast pole cap of aluminum or a pole cap of spun aluminum.

A cast pole cap shall be made of aluminum, in accordance with ASTM B 179, alloy ANSI 319.1 or 319.2. The cap shall fit freely on the 4 1/2 in. (114 mm) outside diameter pole. A set screw using a 3/4 in. (19 mm) No. 12 hex head machine screw shall be supplied to hold the cap on the pole. A standard foundry draft will be allowed on the casting.

A pole cap made from spun aluminum shall be in accordance with ASTM B 209 (B 209M), alloy 1100-0. The cap shall fit tightly when placed on the end of the pole.

922.10 Signal Supports

(a) Steel Strain Pole

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The steel strain pole shall be an anchor base type pole and shall include a handhole and a pole top or cap. The poles shall be furnished in lengths specified.

The pole shall have a reinforced handhole within 18 in. (460 mm) of the base. The handhole minimum size shall be 5 by 8 in. (130 by 200 mm) with a cover and latching device. The pole shall have a top or cap with a set screw that can be removed with small hand tools.

The pole material shall be in accordance with ASTM A 595 or A 572 with a minimum yield strength of 50,000 psi (345 MPa). The pole shall be galvanized after fabrication in accordance with ASTM A 123.

All hardware, handhole cover and latching device, band type steel polebands, steel bolts, nuts, and washers shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153, class C. All nuts and bolts, except anchor bolts, shall be in accordance with ASTM A 307. If a cast pole top or cap is used it shall be in accordance with ASTM A 126 and shall be galvanized with a minimum coating of 2 oz/sq ft (0.610 kg/m^2).

The polebands shall fit the pole as planned. The wire rope shall not be in contact with any 90° edges or with any threads on the band. The pole band material shall be in accordance with ASTM A 572, grade 50 (A 572M, grade 345); ASTM A 606; or ASTM A 36 (A 36M) with minimum yield of 50,000 psi (345 MPa). The minimum width of the bands shall be 3 in. (75 mm) and the bands shall be capable of supporting the pole design load. Each half of the band shall be stamped with the corresponding size number.

All welding shall be in accordance with 711.32. Welds shall generate the full strength of the shaft. Only longitudinal continuous welding shall be permitted on the pole shaft. Contacting joint surfaces shall be thoroughly cleaned before fabrication then completely sealed by means of welding. Working drawings shall be submitted in accordance with 105.02.

The pipe coupling for the weatherhead and base plate shall be installed prior to galvanizing. The threads shall be cleaned of all excess galvanizing. An internal J-hook shall be installed near the top of the pole for wire support.

The steel strain pole shall be capable of supporting a 8,000 lb (35.6 kN) load applied horizontally 18 in. (460 mm) below the top of the pole with a maximum allowable deflection of 0.16 in. (4.1 mm) per 100 lb (445 N) of load. The pole shall be tapered 0.14 in./ft (12 mm/m) of length.

A one piece base plate shall be secured to the base of the pole and shall develop the full strength of the pole. The base plate material shall be in accordance with ASTM A 36 (A 36M), A 572 (A 572M), or A 588 (A 588M). The base plate shall have 4 holes of adequate size to accommodate 2 1/4 in. (57 mm) anchor bolts. The bolt circle shall have a 22 in. (560 mm) diameter and bolt square of 15 1/2 in. (394 mm).

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Four high strength steel anchor bolts, 2 1/4 in. (57 mm) in diameter and 96 in. (2,400 mm) long, including the hook, shall be furnished with each pole. Each bolt shall have 2 hex nuts and 2 washers in accordance with ASTM A 307, grade A. The anchor bolt material shall be in accordance with ASTM A 576 or ASTM A 675 (A 675M) with a minimum yield strength of 55,000 psi (379 MPa) or ASTM A 36 (A 36M), special quality, modified to 55,000 psi (379 MPa) or approved equal. The threaded end of the anchor bolt shall have 12 in. (305 mm) of 4 1/2 NC threads and shall be galvanized the length of the threads, plus 3 in. (75 mm). The threaded end shall be coated after fabrication in accordance with ASTM A 153 or be mechanically galvanized and be in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C. The unthreaded end of the anchor bolt shall have a standard L bend for a distance of 9 in. (230 mm) from the centerline of the anchor bolt to the end of the L. In lieu of the standard bend a steel plate 4 1/2 sq in. (2,900 mm^2) and 1 1/4 in. (32 mm) thick may be welded to the embedded end of the anchor bolt.

(b) Wood Strain Pole

Wood strain poles shall be made from southern yellow pine and shall be in accordance with the current ANSI Specifications and Dimensions for Wood Poles No. 05.1. They shall be of the length and class specified.

All poles shall be full length pressure treated by the full cell process in accordance with current specifications as set forth in the AWPA Standards C1 and C4, using preservative as outlined in standard P5 and set forth in 911.02(h).

Treatment, handling, and storage methods shall be in accordance with the current AWPA Standards.

(c) Signal Cantilever Structures

1. General

All traffic signal cantilever structures, with or without combination arm, shall be as shown on the plans.

There shall be no threads in the wearing surface plane at the point of connection between the clevis clamp and the signal face assembly. The clevis clamp shall have an 11/16 in. (18 mm) diameter bolt hole to receive the signal face assembly.

The signal cantilever structure pole, sections 1 and 2, signal arm, and combination arm shall be a round or multi-sided tapered tube, except the upper 4 to 6 ft (1.2 to 1.8 m) of a signal pole may be non-tapered. The pole and arms taper rate shall be 0.14 in./ft (12 mm/m). The signal cantilever structure poles shall have a reinforced handhole as shown on the plans. A 1/2 in. (13 mm) 13 NC threaded grounding nut or approved equivalent shall be provided and be accessible through the handhole. The pole cap shall be secured in place with setscrews. The pole shall be provided with a removable pole cap and integral wire support hook for the luminaire electrical cable. The cable shall be attached to the hook by a service drop clamp.

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The signal cantilever arm and combination arm, if required, shall be attached to the pole as shown on the plans. The arms shall have cable inlets as shown on the plans. All signal heads on the arm shall be attached as shown on the plans and installed parallel to the horizontal plane and centered to the cantilever arm. The cantilever arms shall be used as an enclosed raceway for wiring and shall be free of burs or rough edges.

The pole top luminaire for roadway lighting, if required, shall be installed on these structures as shown on the plans.

2. Base Plate

A one piece anchor base shall be supplied as shown on the plans. Four removable bolt covers shall be provided with each base and each cover shall attach to the upright portion of the body of the base by means of 1 hex head cap screw.

3. Materials

The signal cantilever pole, arms, base plates, arm flange plates, gusset plates, ring stiffeners, and pole splice plates shall be in accordance with ASTM A 595 or A 572 with a minimum yield strength of 50,000 psi (345 MPa).

4. Hardware

Bolts for the pole splice shall be in accordance with ASTM A 490 and shall be galvanized. The contact area for both pole splice plates shall be class B in accordance with AASHTO 10.32.3c with a minimum slip coefficient of 0.5. The surfaces shall be blast cleaned with class B coatings. The arm flange plate connection bolts shall be in accordance with ASTM A 325. All other hardware shall be in accordance with ASTM A 307 and galvanized in accordance with ASTM A 153, or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C. A cast pole cap shall be in accordance with ASTM A 126 and shall be galvanized with a minimum coating of 2 oz/sq ft (0.610 kg/m^2).

5. Anchor Bolts

Four steel anchor bolts, each fitted with 2 hex nuts and 2 flat washers, shall be furnished with each pole. The anchor bolt shall be as shown on the plans with a minimum of 15 in. (380 mm) of 7 NC threads on the upper end. The threads, nuts, and washers shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153. The steel for the bolt shall be in accordance with ASTM F 1554, with a yield strength of 36,000 psi (248 MPa) or 55,000 psi (379 MPa), or approved equal.

6. Finish

All steel material shall be fully galvanized. Galvanizing shall take place after all welding is accomplished and holes cut.

7. Certification

Unless otherwise specified, all materials covered herein shall be covered by a type C certification in accordance with 916.

8. Working Drawings

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Working drawings and design calculations shall be submitted in accordance with 105.02.

(d) Downguys, Anchors, Rods, and Guards

Pole anchors shall be 8 way expanding with a minimum area of 135 sq in. (87,100 mm^2) when expanded or a 10 in. (250 mm) diameter screw anchor. They shall have a minimum holding strength of 10,000 lb (44.5 kN). They shall be painted and in accordance with ASTM A 569 (A 569M). Anchor rods for expanded anchors shall be 3/4 in. (19 mm) diameter steel and for screw anchors shall be 1 1/4 in. (32 mm) diameter steel, 8 ft (2.4 m) long, in accordance with ASTM A 659 (A 659M), and be galvanized in accordance with ASTM A 153.

Guy guards shall be made of 18 gauge galvanized steel, polyethylene, polyvinylchloride, or melamine phenolic, and shall be 7 ft (2.1 m) long. The steel guy guard shall have a tight gripping, non-scarring hook for quick attachment to the guy wire. The bottom shall have a clamp that fits over the anchor rod and securely grips by tightening the bolt. Steel guy guards shall be in accordance with ASTM A 659 (A 659M). The nonmetallic guy guard shall be a helical pigtail which shall resist upward movement, a lock strap to secure the lower end, and a guy guard sleeve. Non-metallic guy guards shall be gray or yellow.

(e) Support Cable

1. Messenger Cable

Messenger cable shall be zinc-coated steel wire strand, contain 7 wires, and have a nominal diameter of 3/8 in. (10 mm). The cable shall be in accordance with ASTM A 475, Siemens-Martin Grade.

2. Span, Catenary, and Downguy Cable

Span, catenary, and downguy cable, shall be aircraft cable for non-aircraft use, and shall be 3/8 in. (10 mm) nominal diameter, made of stainless steel wire, and consist of 7, 19 wire flexible steel strands. The 3/8 in. (10 mm) cable shall have a minimum breaking strength of 12,000 lbs (53.4 kN). It shall be in accordance with Military Specifications MIL-W-83420D.

3. Tether and Support Cable

Tether and support cable shall be aircraft cable, for non-aircraft use, and shall be 3/16 in. (5 mm) nominal diameter, made of stainless steel wire, and consist of 7, 7-wire flexible steel strands. The 3/16 in. (5 mm) cable shall have a minimum breaking strength of 3,700 lbs (16.5 kN). It shall be in accordance with Military Specifications MIL-83420D.

4. Cable Hardware

(a) Messenger Hangers

Messenger hangers shall be either a 3-bolt clamp or a 3/8 by 1 3/4 in. (10 by 44 mm) steel hanger with a 90° bend extending from the pole 3 3/4 in. (95 mm). The hanger

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shall have a curved groove and clamp capable of receiving a 5/16 to 1/2 in. (8 to 13 mm) cable.

The messenger shall be clamped by two 1/2 in. (13 mm) high carbon steel bolts. The angle hanger shall be mounted with a 5/8 in. (16 mm) through bolt and a 1/2 in. (13 mm) lag screw. The 3-bolt clamp shall be mounted with a 5/8 in. (16 mm) through bolt. The angle hanger shall be in accordance with ASTM A 575. The bolts shall be in accordance with NEMA PH 23.

(b) Cable Ring

Cable rings shall be galvanized steel in accordance with IMSA 51-1.

(c) Clamps

Clamps shall be made of 3/8 in. (10 mm) steel and in accordance with ASTM A 575.

Two bolt clamps shall be a minimum of 3 3/4 in. (95 mm) long and 1 1/4 in. (32 mm) wide with two 1/2 in. (13 mm) bolts which shall clamp cable of 1/8 to 1/2 in. (3 to 13 mm) diameter.

Three bolt clamps shall be a minimum of 6 in. (150 mm) long and 1 5/8 in. (42 mm) wide with three 5/8 in. (16 mm) bolts which shall clamp cable of 5/16 to 1/2 in. (8 to 13 mm) diameter.

The bolt heads shall be large enough to provide maximum clamping area and shall have oval shoulders to prevent the bolts from turning while tightening. The bolts shall be in accordance with NEMA PH 23.

(d) Servi-Sleeves

Servi-sleeves shall be 1 1/4 to 2 1/4 in. (32 to 57 mm) in length and shall hold the size of the cable specified. The sleeves shall be in accordance with ASTM A 659 (A 659M).

(e) Straight Eye-Bolts

Straight eye-bolts shall be 3/4 in. (19 mm) diameter drop forged steel, a minimum of 14 in. (356 mm) long, and have 6 in. (150 mm) of thread. The steel washers shall be 2 1/4 by 2 1/4 by 3/16 in. (57 by 57 by 5 mm) in size with a 13/16 in. (21 mm) hole in the center. All parts shall be in accordance with ASTM A 575 and shall be galvanized in accordance with ASTM A 123.

(f) Hub-Eyes

Hub-eyes shall be made of drop forged steel and in accordance with ASTM A 575. They shall receive a 3/4 in. (19 mm) mounting bolt and have a full rounded thimble eye for protection of the guy cable.

922.11 Signal Cable

(a) Hook-up Wire

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Signal hook-up wire shall be stranded 1 conductor wire, type THW 7 strand No. 14 AWG, with a thermoplastic sheath 3/64 in. (1.19 mm) thick and a 600 volt rating. Insulation shall be color coded, as required, and labeled with gauge, voltage rating, and insulation type.

(b) Signal Control Cable

Signal control cable shall be in accordance with IMSA 19-1 or 20-1 and shall be stranded No. 14 AWG wire.

(c) Service Cable

Traffic signal service cable shall be color coded, stranded copper No. 8 AWG wire, 3 conductor cable, type THWN.

922.12 Signal Interconnect

(a) Integral Messenger Interconnect Cable

Integral aerial interconnect cable shall be figure "8" self-supporting type cable consisting of a messenger cable and 7 conductors No. 14 AWG signal cable in accordance with IMSA 20-3.

(b) 6 Pair/19 Telemetry Cable

6 pair telemetry cable shall contain 6 twisted pairs of 19 gauge conductors and shall be in accordance with IMSA 40-2 for underground application and IMSA 40-4, integral messenger, for aerial application.

(c) Fiber Optic Interconnect Cable

Fiber optic cable shall contain 6 stranded multimode, graded index, optic fibers with a minimum of 1 non-metallic central strength member. The cable shall be loose tube, all dielectric construction, suitable for outdoor use in conduit or on aerial supports.

Each individual fiber shall be 62.5/125 µm diameter, core/clad, and each fiber shall be individually encased in its own gel-filled color-coded buffer. The fiber optic cable shall be constructed with Kevlar braid and outer polyethylene jackets as a minimum. If an inner jacket is used it shall be PVC. Maximum attenuation of the cable shall be 4.0 dB/km nominal, measured at room temperature at 850 nm. The bandwidth shall not be less than 160 MHz/km, also at 850 nm. Each fiber shall be continuous with no factory splices except for joining standard length cables to form longer, continuous jacketed cable to fit installation requirements. The cable shall have standard nylon rip cords. Kevlar rip cords will not be accepted. The cable shall be in accordance with the generic requirements for optical fiber and optical fiber cable per Bellcore Technical Reference TR-TSY-000020.

The exterior of the polyethylene outer cable jacket shall be stenciled so that every fifth meter on each reel is marked with a number. The fifth meter of each reel shall be marked with a 5, the tenth meter marked with a 10, and so on until the end of the reel. The stencil shall be applied to the outer jacket using permanent ink and shall be permanently engraved into the jacket to provide long lasting readability.

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922.13 Detection Components

(a) Loop Detector Lead-in Cable

Runs 700 ft (213 m) and less of loop detector lead-in cable shall be in accordance with IMSA 50-2 and shall be stranded 2 conductor No. 16 AWG, 19 strands of No. 29 wire. Runs greater than 700 ft (213 m) shall use 14 AWG wire.

The nominal capacitance between conductors shall be 57 pF/ft (187 pF/m) and 98 pF/ft (322 pF/m) between one conductor and the other conductor connected to the shield.

(b) Roadway Loop Wire

Roadway loop wire shall be 14 AWG gauge IMSA 51-7 duct-loop wire with polyvinyl chloride or polyethylene outer jacket of 1/4 in. (6.3 mm) diameter.

(c) Preformed Pave-Over Loops

All components of preformed pave-over loops designed for HMA paved-over application shall have a minimum temperature rating of 300°F (150°C). Preformed pave-over loops shall be selected from the Department's list of approved Traffic Signal and ITS Control Equipment.

The size of a preformed pave-over loop shall be 6 ft (1.83 m) diameter, 18.9 ft (5.75 m) circumference round or 6 ft (1.83 m) octagonal, 20 ft (6.1 m) perimeter. The loops placed in the same lane shall be spaced 15 ft (4.57 m) from the center of one loop to the center of the next loop.

Preformed pave-over loops may be constructed as a single loop or as 2, 3 or 4 loops in series. Each individual loop shall be wired with 4 turns of wire unless otherwise specified. Loops constructed in a series shall also be wired in series.

(d) Microloop Detectors

Materials for microloop detectors shall be selected from the Department's approved materials list. The microloop detectors selected shall be capable of counting vehicles in addition to detecting vehicle presence.

Each microloop detector location shall include the following items:

1. *Non-invasive probe, lead-in cable and carriers for microloop detector as shown on the plans;*

2. *3-in. diameter schedule 80 PVC conduit containing the probes, lead-in cable and carriers;*

3. *Buried service wire encapsulation kit compatible with microloop detector for all splicing between the lead-in cable and the home run cable;*

4. *Installation kit, one for each conduit containing probes;*

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5. *All mounting hardware, conduit bushings, wiring, connectors, grounding wires, ground rods, grounding cables, etc., necessary to complete the microloop detector location installation.*

922.14 Ground Wire

The ground wire shall be copper wire No. 6, AWG soft-drawn, solid copper in accordance with ASTM B 3.

922.15 Splicing Kit

Splicing kits shall contain a 2 piece, transparent snap-together mold body and include an epoxy and sealing compound contained in a unipak. It shall be capable of insulating and splicing nonshielded cables rated up to 5 kilovolts and multi-conductor cables rated up to 600 volts.

922.16 Ground Rod and Connections

Ground rods shall be 1/2 in. (13 mm) in diameter by 8 ft (2.4 m) long with a machined point and chamfered top. They shall be made of steel with a molecularly bonded outer layer of electrolytically applied copper. A single electrode shall have a maximum resistance to ground of 25 ohms. Single electrodes that do not have resistance to ground of 25 ohms or less shall be augmented by additional electrodes, grids, or plates until resistance to ground of 25 ohms or less is achieved. Resistance shall be measured using a 3-point ground tester using the fall of potential method. Data, graphs, resistance in ohms, date of test, make and model of ground tester, and the individual's initials performing the test shall be recorded and submitted to the District Office. Resistance in ohms shall be tagged at the ground connection.

The finished rod shall be cold-drawn and shall have the following minimum physical properties:

PHYSICAL PROPERTY	*MINIMUM*
Tensile strength	*97,000 psi (668 MPa)*
Yield strength, 0.2% offset	*85,000 psi (586 MPa)*
% of elongation	*13 psi (90 kPa)*

The ground rod and wire connection shall be made by a thermo weld process or approved equal. The welding material shall cover and secure the conductor to the rod and shall be porous free.

An acceptable alternate shall be a ground grid connection properly sized and shall consist of a shear head bolt, a "C" shaped body, nest, and wedge. The connector components shall be fabricated from an aluminum-bronze alloy, silicone-bronze alloy, and copper.

922.17 Castings for Handholes

The ring and cover for handholes shall be in accordance with 910.05(b).

922.18 Entrance Switch

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The entrance switch shall be a double pole, 50 A, 120V AC circuit breaker in a NEMA type 3R enclosure. The minimum dimensions of the enclosure shall be: 5 in. (127 mm) wide, 3 3/4 in. (95 mm) deep and 9 1/4 in. (235 mm) height. A 1 in. (25 mm) rain-tight detachable hub shall be supplied in the top of the enclosure. The enclosure shall have knockouts on the sides, bottom and back with diameters of 7/8 in. (22 mm) to 1 3/4 in. (44 mm). The enclosure shall contain the circuit breaker, an insulated solid bar for connection of AC neutral, a separate lug for attachment of earthground, have provisions for a padlock, and shall be surface mounted.

The enclosure shall be made of galvanized steel with a rust inhibiting treatment and finished in the manufacturer's standard color of baked enamel.

All wire terminations and breaker to buss-bar contact points inside the enclosure shall be coated with an anti-oxidant to prevent oxidizing and corrosion of components.

922.19 Conduit and Fittings

(a) Steel Conduit

Steel conduit, couplings, and elbows shall be galvanized rigid steel conduit in accordance with UL 6. The conduit shall be galvanized by the hot dip method on the interior and exterior surfaces. Conduit threads shall be cut after galvanizing. The conduit shall be supplied with a threaded coupling attached to one end and the other threaded end protected by a suitable shield.

The various conduit fittings such as bands, bodies, straps, lock nuts, and threadless connectors, shall be in accordance with Federal Specifications A-A-50553 and shall be galvanized if not stainless steel. Conduit straps shall be 2 hole straps with a minimum thickness of 1/8 in. (3 mm). Conduit lock nuts 3/8 to 1 1/2 in. (10 to 38 mm) in size shall be made of steel. Other sizes shall be made of either steel or malleable iron. All conduit lock nuts shall be galvanized. Other nuts shall be either stainless steel or galvanized steel.

(b) Polyvinyl Chloride, PVC, Schedule 40 or 80 Conduit

Conduit, fittings, and accessories shall be manufactured from polyvinyl chloride meeting ASTM D 1784 and shall comply with all the applicable requirements of NEMA TC2 and UL 651. Each length of pipe shall include tracer wire and a coupling.

(c) Fiberglass Conduit

Rigid fiberglass conduit and fittings shall be filament wound consisting of E-glass and corrosion resistant epoxy resin manufactured for use at temperatures from -40 to 230°F (-40 to 110°C). Rigid fiberglass conduit shall be pigmented with carbon black for ultraviolet protection and fire resistant per UL 94. All rigid fiberglass conduit shall have tracer wire, be heavy walled, HW, and meet the specifications, labeling and testing of ANSI/NEMA TC14.

922.20 Detector Housing

The entire housing casting shall be made from aluminum alloy in accordance with ANSI 320.

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922.21 Certification

Unless otherwise specified, all materials covered herein shall have a type C certification in accordance with 916.

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