TRAFFIC SIGNAL MATERIALS AND EQUIPMENT

The Standard Specifications are revised as follows:

SECTION 913, DELETE LINES 2299 THROUGH 4050.

SECTION 913, AFTER LINE 4051, INSERT AS FOLLOWS:

913.15 Traffic Signal Materials and Equipment. *All traffic signal materials and equipment shall be in strict accordance with the NEMA TS 2-2003 Standards Publication, and be fully compatible with the Department's current inventory of signal equipment, unless specifically outlined in the following specification.*

(a) Traffic Signal Controller Assembly.

1. Model Approval. *Each model of controller assembly (CA) and all major units, as defined in NEMA TS2-2.1.1, will be tested, evaluated by the Evaluations Section of Operations Support Division, 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(s) (BIUs), Cabinet Power Supply, Load Switches, Vehicle Detector equipment, 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(s), the operational manual(s) containing procedures for all features incorporated in the CU's design, and the maintenance manual(s) containing all schematics, pictorial parts layouts, components parts listings, and documented theory of operation. Certification in accordance with 913.15(a)4 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, two more rejections of a product submitted for evaluation will be cause to deny approval of that model permanently.*

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 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. 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.

2. 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. The Contractor shall prepare three packets for each CA and provide these packets to the Engineer. Packet 1 shall consist of one complete set of wiring and schematic diagrams for the CA's TF Backpanel, a parts list indicating model name and serial number of all major units incorporated in the CA, and an 11 in. x 17 in. intersection design plan. Also included shall be an instructional programming manual identical in nature to that approved for use during the evaluation of the product(s) being supplied. Each packet shall be labeled with the name of the intersection, the contract number, the commission number and the date of installation. Packet 1 will be forwarded to the Operations Support Division, Highway Support Section, and shall be the responsibility of the vendor to provide this packet upon Contractor purchase. Packet number 2 will be retained in the controller assembly and shall additionally include a TS2 type 2 to TS2 type 1 adapter harness. Packet 3 will be retained by the District Traffic Office.*

The Department will maintain a list of approved models. Only models from the Department's list of approved Traffic Signal Control Equipment in effect as of the date of letting, or as otherwise specified, shall be used in the contract.

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.

3. Warranty*. A five-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 five-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 I.C. 636a form if purchased through a contracting agent.*

4. Certification of NEMA TS2 Traffic Control Equipment. The following certifications shall be furnished.

a. 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 five 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 913.15 (a) 1 to the circuitry in the product.

b. 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.

5. 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 two types of CUs, 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.

a. General Requirements. The CU shall be microprocessor based and both versions shall contain a three 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.

b. 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 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-Section 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 version 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.

c. 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.

d. 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.

e. Firmware and Software Revisions. *The Operations Support Division Evaluations Section 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. Operations Support 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.*

6. 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, & 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.*

a. Controller Cabinet Requirements*. The NEMA TS2 Type A1 controller cabinet shall be in accordance with the following requirements.*

(1) General*. The cabinet and the shelf or shelves shall be fabricated of aluminum. The cabinet shall be 3.175 mm (0.125 in.) minimum thickness sheet aluminum or 6.35 mm (0.25 in.) 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 two 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 two 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 38 mm (1.5 in.) 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 one complete set of cabinet prints and manuals. This drawer shall support 23 kg (50 lb) 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 610 mm (24 in.) wide.

(2). 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 two different switches, one switch for field indication cutoff and one switch to transfer between automatic signal control and flashing operation. The switches shall be protected from water when the cabinet door is open.*

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 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.

The cabinet shall contain one 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, three-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-amp cartridge fuse wired ahead of the multi-breakers.

The cabinet shall contain a thermostatically controlled ventilating fan and a vent with a commercially classified uniform 25 mm (1 in.) thick filter. The thermostat shall be manually adjustable from 33 to 45°C (90 to 115°F). 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 3 m^3 (100 ft^3) per minute as designated by NEMA TS2, Section 7.9.1. The thermostat shall be located within 150 mm (6 in.) of the fan.

The filter size will be according to the provisions for the type of cabinet as stated in NEMA TS2, Section 7.9.2.3 and shall be a replaceable air filter. The cabinet ventilation shall be in accordance with NEMA TS2-7.9. The size 5 (M) and size 6 (P-1)

cabinets shall have inlet air ventilation openings in the cabinet door of adequate size to allow sufficient air flow per the rated fan capacity within the cabinet.

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

Master cabinets shall have an additional duplex, three-prong, NEMA Type 5-15R grounding outlet. Master cabinets shall have a separate power interrupt switch controlling the master CU power supply.

b. Load Switch and Flasher Requirements. *The cabinet shall contain a jack mounted type 3 solid state non-repairable flasher in accordance with NEMA Standards 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 115 volts AC line input or signal buss output. Each load switch shall offer three indicators, one 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 CA shall be accomplished through front panel data entry of a TS2 Type A1 or a TS2 Type A2 CU.

c. Terminal and Facilities Requirements.

(1) 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 section 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 1-microfarad 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 24 volt 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.

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. RS-485 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 RS-485 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 one circuit for odd numbered phases and on the other circuit for even numbered phases.

(2) 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-ampere circuit breaker to provide overload protection to the CU, MMU, BIU, +12/24 VDC cabinet power supply, and detection devices. It shall also contain one main circuit breaker of 35 or 40 ampere, to provide over-load protection to the signal and flash buss load. All breakers shall have line and load terminals clearly labled. 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 ampere and Main 35 - 40 ampere circuit breakers off (tripped), all units inside the cabinet and the intersection display shall be off. With the 10-amp breaker on and main 35 - 40 ampere circuit breaker off, the signal output shall be off and the major units within the cabinet shall function. With the 10-amp breaker off and main 35-40 ampere circuit breaker on, the intersection shall be in flash mode and all units within the cabinet will be off.

The cabinet shall contain a surge suppressor. The surge suppressor shall be wired behind the multi-breaker, in parallel with the 35 - 40 amp main signal buss circuit breaker and in series with the 10-amp circuit breaker for the solid state equipment. The surge suppressor shall have a maximum clamp voltage of 350 volts at a peak current of

20,000 amps for a minimum of 20 occurrences. The surge suppressor shall operate between -34 to 74°C (-30 to 165°F). The dimensions of the unit shall not exceed 80 mm (3.25 in.) wide by 150 mm (6 in.) long by 64 mm (2.5 in.) deep.

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

e. 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.*

f. Loop Amplifier Units and Rack Requirements.

(1) Loop amplifier units shall be in accordance with NEMA TS2-Section 6 and shall follow type C, 2 channel with delay and extend, as stated in NEMA TS2-6.5.2.2.1. In addition, loop amplifiers shall have an LCD display or a RS-232 serial data connection and software interface capable of displaying loop status, diagnostics, and all amplifier settings and operating parameters. Two channel counting amplifiers shall additionally transmit channel 1 & 2 count pulses on the edge connection assigned to channels 3 & 4 respectively, shall be configured with count outputs mapped to and recorded in the CU detector logs, and shall be approved by the Department for counting purposes. 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.

(2) All size 5 (M) & size 6 (P-1) cabinets shall incorporate a 16 channel detector rack, configuration #2, as per NEMA TS2-5.3.4 and shall allow operation of a two channel detector in each slot and the capability of operation of a four channel detector in each even-numbered slot. All size 3 (G) cabinets shall incorporate an 8 channel detector rack, configuration #1, as per NEMA TS2-5.3.4.

g. 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.*

7. Cabinets.

a. 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*

one adjustable shelf located 305 mm(12 in.) below the top of the cabinet. The bottom of the cabinet shall be reinforced to ensure a secure pedestal mounting. The G cabinet shall have dimensions of 635 mm (25 in.) wide, 965 mm (38 in.) high, 460 mm (18 in.) deep with a tolerance of + 100 mm (4 in.) in all dimensions.

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

b. Size 5 (M) Cabinet. *As per NEMA TS2-5.3, The TS2 type-1 size 5 (M) cabinet, as a minimum, shall house at minimum an 8- load switch bay (configuration 2) terminal and facilities panel and shall have two adjustable shelves with the first shelf located 380 mm (15 in.) below the top of the cabinet and the second located 180 mm (7 in.) 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 760 mm (30 in.) wide, 1220 mm (48 in.) high, and 410 mm (16 in.) deep with a tolerance of ± 50 mm (2 in.) in any or all dimensions.

Anchor bolts shall be steel in accordance with ASTM A 36M (ASTM A 36). Diameter of the bolt shall be 13 mm (1/2 in.) or 16 mm (5/8 in.) and the minimum length shall be 380 mm (15 in.) plus a 75 mm (3 in.) right angle hook on the unthreaded end. The top 150 mm (6 in.) of the bolt shall be threaded with 13 NC threads on 13 mm (1/2 in.) bolts and 11 NC threads on 16 mm (5/8 in.) 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.

c. 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 913.15(a)7b. As per NEMA TS2-5.3, The TS2 type 1 P cabinet, at minimum, shall house a 12 load switch bay (configuration 3) terminal and facilities panel and shall have two adjustable shelves with the first shelf located 510 mm (20 in.) below the top of the cabinet and the second located 180 mm (7 in.) below the first shelf.*

The cabinet shall be 1120 mm (44 in.) wide, 1320 mm (52 in,) high, and 610 mm (24 in.) deep with a tolerance of ± 75 mm (3 in.) in all dimensions. Maximum exterior dimensions shall be 860 mm (34 in.) deep, 1195 mm (47 in.) wide, and 1600 mm (63 in.) high.

(b) 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 Light Emitting Diodes, LED, with the exception of the solid amber ball indication on heads containing red, amber, and green indications, which shall be incandescent lamp. All LED indications shall be selected from the Department's list of approved Traffic Signal Control Equipment.

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

2. 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 degree increments. Hub openings in the top and bottom of the signal housing shall accommodate standard 38 mm (1 1/2 in.) bracket arms. The thickness of the hub at the top and bottom of the housing shall be a maximum of 25 mm (1 in.) and a minimum of 10 mm (3/8 in.). The 305 mm (12 in.) door shall have two 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.

3. Lens. The lens shall be made of plastic and shall be in accordance with ASTM D 788, grade 8; ASTM D 702, grade 3; or ASTM D 3935. The index of refraction shall be between 1.48 and 1.59. The lens shall be uniformly colored throughout the body of the material, true to size and form, and free from any streaks, wrinkles, chips, or bubbles. The values of luminous transmission for the signal lens and the limits of chromaticity for the lens colors shall be in accordance with the Institute of Transportation Engineers for Adjustable Face Vehicular Traffic Control Signal Heads. The lens hole with the lens gasket in place shall be of sufficient size to accommodate a 305 mm (12 in.) diameter lens.

4. Reflector Assembly. The reflector shall be made of Specular Alzak Aluminum. The reflector assembly shall be designed so that it is pivoted and can be swung out of the housing and easily removed without the use of tools. A neoprene gasket shall be provided between and completely around the reflector and the reflector frame and shall be reusable. The reflector frame shall be aluminum or plastic.

5. Lamp Receptacle and Wiring. The lamp receptacle shall be fixed focus type, positioning the lamp filament at the correct focal point with respect to the reflector. The assembly shall be designed so the lamp socket can be rotated through 360 degrees into positions of adjustment for proper positioning of the lamp filament after re-lamping. The lamp socket shall be equipped with color coded wire either red, yellow, or green corresponding to the lens color of the section. Brown may be used for representation of the green lens color. The socket wires shall be a minimum of 660 mm (26 in.) long, fixture wire No. 18 AWG or larger, 600 volts, with insulation designed to withstand 105°C (221°F). The conductor size, insulation type letter designation, and temperature

rating shall be marked on the insulation or a material certification of compliance shall accompany each signal head combination. The wiring leads shall be terminated with screw spade lug type or female type connectors for ease of connection to the terminal block. The socket shall be equipped with a reusable gasket to insure a dust-tight fit between the socket and reflector.

6. Section Coupling. *Any method to connect two or more sections together may be used, if the following requirements are met:*

(a) Two or more sections, when jointed together, shall maintain structural integrity when loaded to Institute of Transportation Engineers Standards.

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

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

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.

7. Terminal Block. *The yellow section of the 3-section signal head shall be equipped with a 5 position terminal block for termination of field wiring. Each section shall have provisions for addition of an 8 position terminal block or two 5 position terminal blocks or one 5 position and one 3 position terminal block. The terminal block shall have a minimum spacing between screw connections of 13 mm (1/2 in.). The height of the insulating ridge between screw connections shall be a minimum of 15 mm (19/32 in.) from the base of the terminal blocks.*

8. Material Requirements.

a. 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)4.*

b. 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, two coats, oven baked and in accordance with 909.02(b) except the inside surface of the visor shall be painted non-reflecting flat black.*

9. 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.

(c) Pedestrian Signal Head. A pedestrian signal shall be one section and rectangular in shape. The dimensions of each side may vary from 460 to 485 mm (18 to 19 in.), including the visor and the hinges. The signal shall contain two figures with two different colored messages. The left figure shall transmit an upraised hand symbol message, and the right 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 Control Equipment. The pedestrian signal shall be in accordance with the standard of the Institute of Transportation Engineers for Pedestrian Traffic Control Signal Indications.

1. 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 38 mm (1 1/2 in.) 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.

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).

2. Optical Unit. The optical unit shall consist of the redirecting lens, the lamp, a reflector, a filter, and other optical elements necessary for proper operation. The optical unit shall be designed to minimize the return of the outside light rays entering the unit, such as sun phantom. The optical unit shall be designed and assembled so that no light escapes from one message unit to the other.

The values of luminous transmission for pedestrian signal lenses and the limits of chromaticity for pedestrian signal colors shall be in accordance with the standard of the Institute of Transportation Engineers for Pedestrian Traffic Control Signal Indications.

3. Lens. The lens shall be made of plastic. The lens shall be in accordance with ASTM D 788, grade 8; ASTM D 702, grade 3; or ASTM D 3935. However, the index of refraction shall be between 1.48 and 1.53. As required by the type of pedestrian signal, the lens shall be uniformly clear or colored throughout the body of the material, true to size and form, and free from any streaks, wrinkles, chips, or bubbles.

4. Message. When illuminated, the upraised hand symbol shall be in Portland Orange on the left surface of the signal indications. The walking person symbol shall appear in white on the right surface of the signal indication when illuminated. The upraised hand and walking person symbols shall each be a minimum of 280 mm (11 in.) in height. The width of the upraised hand symbol shall be a minimum of 178 mm (7 in.). The width of the walking person symbol shall be a minimum of 150 mm (6 in.). 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.

(d) Signal Bulbs. The minimum design requirements for 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:

1. LED Traffic Signal Indicators. All new traffic signal and flasher installations that include new indications shall be fitted with LEDs with the exception of the solid amber ball indication on heads containing red, amber and green indications, which shall be incandescent lamps. All LED indications shall be selected from the Department's list of approved Traffic Signal Control Equipment.

All LED indications shall have a permanent indelible sticker affixed indicating month and year of initial installation.

2. Incandescent Bulbs.

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

INDICATION	*WATTAGE*
230 mm (9 in.) pedestrian	*67*
305 mm (12 in.) and 455 mm (18 in.) pedestrian	*116*
200 mm (8 in.) red, yellow and green	*67*

305 mm (12 in.) red	*150*
305 mm (12 in.) yellow and green	*116*
305 mm (12 in.) yellow and green arrows	*150*
optically programmed heads	*150*

All bulbs shall have medium size, brass bases.

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

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

d. The filament shall be C9 design with a minimum of seven supports. The 2 voltage supply leads may be counted as two of the seven supports.

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

f. All bulbs shall be clear and shall be 130 volt.

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

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

i. All bulbs shall have 6000 h minimum burning life.

(e) 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, nonferrous 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 1.6 mm (0.062 in.). The span hanger bolt where the eye-bolt or the balance adjuster is attached shall be 16 mm (5/8 in.) 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 4.8 mm (3/16 in.) and a maximum thickness of 6.4 mm (1/4 in.) from the base of the ring to the serration peaks. The inside diameter shall be 50 mm (2 in.) and the outside diameter shall be 73 mm (2 7/8 in.).

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 (2.0 mm) wires.

The disconnect hanger shall have two side entrance holes on opposite sides capable of receiving a 38 mm (1 1/2 in.) plastic or rubber insert to reduce water infiltration. It shall be capable of supporting signal faces in the ambient temperature range of -35 to 49°C (-35 to 120°F) 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 two J-bolts, lock washers, and hex head nuts adequate in size to securely fasten the hanger to a messenger cable up to 13 mm (1/2 in.) in diameter.

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

(f) Free Swinging Signal Support Assemblies. *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 1.6 mm (0.062 in.). No bushings or shims will be allowed in this assembly.*

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.

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 64 mm (2 1/2 in.) of exposed threads. The weatherhead shall have two set screws to fasten the nipple to the weatherhead. If the weatherhead and threaded pipe has a slipin 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 two each of J-bolts, lock washers, and hex head nuts. The J-bolt shall be a minimum of 6.4 mm (1/4 in.) diameter and shall have sufficient threads to be able to secure the hanger to a 6.4 mm (1/4 in.) or a 13 mm (1/2 in.) messenger cable. 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, 38 mm (1 1/2 in.) 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 50 mm (2 in.) of exposed thread. Each arm of the pipe arm shall be furnished with two 72 serration locking rings. One locking ring shall have a 75 mm (3 in.) outside diameter and one locking ring shall have a 60 mm (2 3/8 in.) outside diameter.

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

(g) Mid-Mast Arm Mount Signal Bracket. *The bracket shall permit the following 4 adjustments:*

1. *rotational adjustment about bracket axis;*
2. *vertical adjustment;*
3. *rotational adjustment about mast arm; and*
4. *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 mast arm.

Upper and lower arms shall be cast from aluminum in accordance with ASTM B 26M (ASTM B 26), alloy 713.0-T5 or 356.0-T6. The vertical support tube shall be extruded from aluminum in accordance with to ASTM B 241M (ASTM B 241), 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.

(h) Pedestal Poles and Cast Aluminum Pedestal Bases. *The pedestal base used for mounting pedestrian signal heads or control cabinets shall be in accordance with 913.15(h)1. The length of the pedestal pole shall be as shown in the plans.*

1. 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 26M (ASTM B 26), alloy ANSI 356.0-T6. The square base shall include an access door and anchor bolts with nuts and washers. The base shall be 8630 mm (13 3/8 in.) square and 380 mm (15 in.) in height ± 6 mm (1/4 in.). The weight shall be 10.0 kg ± 2.2 kg (22 lbs ± 5%).

The base shall be designed to support a 68 kg (150 lb.) axial load and 1.0 m^2 (11 ft^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 5.5 m (18 ft). 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 200 mm by 210 mm ± 6 mm (8 in. by 8 1/4 in. ± 1/4 in.) with a stainless steel hex head bolt for attaching the door.

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

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.

2. Pedestal Pole. *The top of the base shall accommodate a pole having a 114 mm (4 1/2 in.) outside diameter. The threads inside the top of the base shall be 100 mm (4 in.) 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 114 mm (4 1/2 in.). The pole shall weigh approximately 16 kg/m (10.8 lbs/ft). 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 64 mm (2 1/2 in.). 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 241M (ASTM B 241) for seamless aluminum alloy, schedule 40, 6061-T6. The outside diameter of the pole shall be 114 mm (4 1/2 in.). The length of the pole shall be as shown on the plans. The pole shall weigh approximately 5.5 kg/m (3.7 lbs/ft). The pole shall have full depth national standard pipe threads on one end of the pole. The length of threads shall be 64 mm (2 1/2 in.) and protected by a suitable shield. The pole shall have a spun finish.

3. 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 114 mm (4 1/2 in.) outside diameter pole. A set screw using a 19 mm (3/4 in.) 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 209M (ASTM B 209), alloy 1100-0. The cap shall fit tightly when placed on the end of the pole.

(i) Signal Supports.

1. Steel Strain Pole. *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 460 mm (18 in.) of the base. The handhole minimum size shall be 130 mm (5 in.) by 200 mm (8 in.) 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 345 kPa (50,000 psi). 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 0.610 kg/m^2 (2 oz/ft^2).

The polebands shall fit the pole as planned. The wire rope shall not be in contact with any 90 degree edges or with any threads on the band. The pole band material shall be in accordance with ASTM A 572M, grade 345 (ASTM A 572, grade 50); ASTM A 606; or ASTM A 36M (ASTM A 36) with minimum yield of 345 kPa (50,000 psi). The minimum width of the bands shall be 75 mm (3 in.) 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. Shop drawings shall be submitted in accordance with 913.15(i)3d10.

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 35.6 kN (8000 lbs) load applied horizontally 460 mm (18 in.) below the top of the pole with a maximum allowable deflection of 4.1 mm (0.16 in.) per 445 N (100 lbs) of load. The pole shall be tapered 12 mm per meter (0.14 in. per foot) 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 36M (ASTM A 36), A 572M (A 572), or A 588M (A 588). The base plate shall have four holes of adequate size to accommodate 57 mm (2 1/4 in.) anchor bolts. The bolt circle shall have a 560 mm (22 in.) diameter and bolt square of 394 mm (15 1/2 in.).

Four high strength steel anchor bolts, 57 mm (2 1/4 in.) diameter and 2,400 mm (96 in.) long, including the hook, shall be furnished with each pole. Each bolt shall have

two hex nuts and two washers in accordance with ASTM A 307, grade A. The anchor bolt material shall be in accordance with ASTM A 576 or ASTM A 675M (ASTM A 675) with a minimum yield strength of 379 kPa (55,000 psi) or ASTM A 36M (ASTM A 36), special quality, modified to 379 kPa (55,000 psi) or approved equal. The threaded end of the anchor bolt shall have 305 mm (12 in.) of 4 1/2 NC threads and shall be galvanized the length of the threads, plus 75 mm (3 in.). 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 230 mm (9 in.) from the centerline of the anchor bolt to the end of the L. In lieu of the standard bend a steel plate 2900 mm^2 (4 1/2 in.^{2}) and 32 mm (1 1/4 in.) thick may be welded to the embedded end of the anchor bolt.

2. 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(g).

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

3. Signal Cantilever Structures.

a. General. *A signal cantilever structure shall be designed in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, except where modified herein.*

Where the manufacturer has wind tunnel test data, they may use drag coefficients based on actual tests. Otherwise, the manufacturer shall use the drag coefficients in Table 1.2.5c.

b. Signal Support. *The traffic signal pole and mast arm shall be designed to support the loads in accordance with the plans in a 129 km/h (80 mph) wind with gusts to 167 km/h (104 mph). Loading shall assume die-cast aluminum heads.*

The traffic signal pole and mast arm shall be designed to provide a 5.3 m (17 ft) minimum clearance at all signals. Clearance shall be the vertical distance from the lowest point of the signal combination to a horizontal plane 75 mm (3 in.) below the base of the mast arm pole or from the lowest point of the signal combination to the pavement surface below the signal combination, whichever governs. Adjustment of the clearance at the installation site shall be by raising or lowering the mast arm along the upper length of the pole. After the pole is anchored to the foundation, the pole design shall permit the mast arm to be rotated 90 degrees in either direction and secured. The cable inlet shall not be obstructed when a field rotation or vertical adjustment of the mast arm is made.

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 a 18 mm (11/16 in.) diameter bolt hole to receive the signal face assembly.

c. Combination Signal-Luminaire Support. *All requirements for a signal support shall apply to a combination signal-luminaire support.*

The minimum design load of the luminaire shall be 24 kg (53 lbs) with a projected surface area subject to wind loading of 0.223 m^2 (2.4 ft^2). If heavier or larger luminaires are used, their actual values shall be used. The required luminaire mounting height shall be in accordance with the plans. Mounting height shall be defined as the vertical distance from the lowest point of the luminaire to the horizontal plane that passes through the base of the pole.

The maximum percentage of allowable stress shall be 80% of the AASHTO Standard Specifications for Group I loads. Vibration dampers shall be furnished as recommended by the manufacturer.

d. Pole Requirements.

1. General. *The pole shall be a round or multi-sided tapered tube, except the upper 1.2 to 1.8 m (4 to 6 ft) of a signal support pole may be non-tapered. The signal support pole shall have a reinforced handhole 100-mm (4 in.) by 150 mm (6 in.) minimum complete with cover and latching device located 460 mm (18 in.) above the base. A 13 mm (1/2 in.) 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 combination signal-luminaire pole shall have a reinforced handhole 100 mm (4 in.) by 200 mm (8 in.) minimum complete with cover and latching device, located 460 mm (18 in.) above the base. The combination signal-luminaire 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. A wiring hole with a 25 mm (1 in.) to 38 mm (1 1/2 in.) inside diameter grommet shall be provided where the luminaire mast arm attaches to the pole.*

2. Deflection. *The maximum allowable horizontal deflection of the pole under maximum loading conditions shall not exceed a deflection angle of 1° 10' from the vertical axis of the pole for any 305 mm (1 ft) section of the pole along the entire length of the pole.*

3. Materials. *The signal pole and the combination signal-luminaire pole shall be steel or aluminum. Steel poles shall be in accordance with ASTM A 595 or A 572 with a minimum yield strength of 345 kPa (50,000 lbs) and shall be galvanized in accordance with ASTM A 123. Aluminum poles shall be in accordance with ASTM B 221M (ASTM B 221) alloy 6063-T6 or 6005-T5, or ASTM B 241M (ASTM B 241), alloy 6063-T6.*

4. Hardware. *All hardware for steel poles except bolts for the mast arm clamps and anchor bolts shall be in accordance with ASTM A 307 and shall be*

galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to 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 0.610 kg/m^2 (2 oz/ft^2).

All hardware for aluminum poles shall be stainless steel in accordance with ASTM A 276, type 304 or type 305.

5. Anchor Base. *A one piece anchor base shall be secured to the lower end of the pole and shall develop the full strength of the pole. The base shall be provided with 4 holes of adequate size to accommodate 32 mm (1 1/4 in.) anchor bolts equally spaced on a bolt circle of 380 mm (15 in.) diameter and shall have four tapped holes for attaching the bolt covers. 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 one hex head cap screw. The steel for the anchor base shall be in accordance with ASTM A 36M (ASTM A 36), A 572M (A 572), or A 588M (ASTM A 488). Aluminum for the anchor base shall be in accordance with ASTM B 26, alloy 356.0-T6 or 356.0-T7 or ASTM B 209, alloy 6061-T6.*

6. Arm Requirements.

a. Signal Cantilever Arm. *A signal cantilever arm shall be attached to the pole by circular clamps. One-half of the clamp shall be welded to the cantilever arm. The single member arm or the upper tapered member of the truss style arm shall have a cable inlet adjacent to the clamp complete with grommet. The cable inlet shall be a 44 mm (1 3/4 in.) diameter hole with a 38 mm (1 1/2 in.) inside diameter rubber grommet. The 6.1, 7.6 and 9.2 m (20, 25, and 30 ft) cantilever arms shall have one intermediate cable inlet with grommet located 3.7 m (12 ft) from the free end of the arm. The 10.7 and 12.2 m (35 and 40 ft) cantilever arm shall have two intermediate cable inlets with grommets located 3.6 m (12 ft) and 7.3 m (24 ft) respectively from the free end of the arm. The intermediate cable inlet shall be 25 mm (1 in.) diameter hole with 19 mm (3/4 in.) inside diameter rubber grommet.*

The maximum rise of the single member arm shall be 13 mm (1/2 in.) per 305 mm (1 ft) of arm after loading. The maximum rise of the truss style arm shall be as set out in the table. The rise shall be measured vertically from the centerline of the free end of the truss to a plane through the centerline of the upper arm bracket after loading.

Mast Arm Length m (ft)	*Total Rise m (ft - in.)*	*Tolerance mm (in.)*
3.7 - 6.1 (12 - 20)	*1.2 (4-0)*	*±25 (±1)*
7.6 (25)	*1.3 (4-3)*	*±25 (±1)*
9.2 - 12.2 (30 - 40)	*1.4 (4-7)*	*± 25 (±1)*

The end signals on the truss style arms shall be suspended and the intermediate signals shall be rigidly attached. All signals on the single member arms shall be rigidly attached as shown on the plans. The cantilever arms shall be used as an enclosed raceway for wiring and shall be free of burrs and rough edges.

Both parts of the clamp for the single member arms shall be stamped with the arm length prior to galvanizing.

b. Luminaire Mast Arm for Combination Support. *The luminaire mast arm shall be in accordance with 913.11(a)1.*

c. Materials. *The signal cantilever arm shall be of the same material as the pole. The luminaire mast arm shall be of the same material as the pole except that a truss type arm shall be in accordance with 913.11(a). Bolts for the mast arm clamp shall be stainless steel in accordance with ASTM A 276, type 304 or 305.*

7. Anchor Bolts. *Four steel anchor bolts, each fitted with two hex nuts and two flat washers, shall be furnished with each pole. The anchor bolt shall be 32 mm (1 1/4 in.) in diameter with a minimum of 254 mm (10 in.) 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, class C. The anchor bolt shall be 1220 mm (48 in.) long with a 100 mm (4 in.) right angle bend on the lower end or a square steel washer, 150 mm by 150 mm by 13 mm (6 in. by 6 in. by 1/2 in.), with a hex nut welded onto the lower end. The steel for the bolt shall be in accordance with ASTM A 576 or ASTM A 675M (ASTM A 675), with a minimum yield strength of 379 kPa (55,000 psi), or ASTM A 36M (ASTM A 36), special quality, modified to 379 kPa (55,000 psi) or approved equal.*

8. Finish. *All steel material shall be fully galvanized. Galvanizing shall take place after all welding is accomplished. Aluminum poles shall be provided with a satin finish accomplished by mechanical rotary grinding and aluminum mast arms shall be provided with a satin etched finish.*

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

10. Shop Drawings. *Five sets of shop drawings and a set of design calculations shall be submitted to the Design Division for approval. A copy of the transmittal letter shall be sent to the Engineer. The approved drawings will be distributed by the Design Division.*

11. Downguys, Anchors, Rods, and Guards. *Pole anchors shall be 8 way expanding with a minimum area of 87 100 mm^2 (135 $in.^2$) when expanded or a 250 mm (10 in.) diameter screw anchor. They shall have a minimum holding strength of 44.5 kN (10,000 lb.). They shall be painted and in accordance with ASTM A 569M (ASTM A 569). Anchor rods for expanded anchors shall be 19 mm (3/4 in.) diameter steel and for screw anchors shall be 32 mm (1 1/4 in.) diameter steel, 2.4 m (8 ft) long, in accordance with ASTM A 659M (ASTM A 659), 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 2.1 m (7 ft) 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 659M (ASTM A 659). 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.

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

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

14. Tether and Support Cable. *Tether and support cable shall be aircraft cable, for non-aircraft use, and shall be 5 mm (3/16 in.) nominal diameter, made of stainless steel wire, and consist of seven, 7-wire flexible steel strands. The 5 mm (3/16 in.) cable shall have a minimum breaking strength of 16.5 kN (3700 lbs). It shall be in accordance with Military Specifications MIL-83420D.*

15. Cable Hardware.

a. Messenger Hangers. *Messenger hangers shall be either a three bolt clamp or a 10 mm (3/8 in.) by 44 mm (1 3/4 in.) steel hanger with a 90 degree bend extending from the pole 95 mm (3 3/4 in.). The hanger shall have a curved groove and clamp capable of receiving a 8 mm to 13 mm (5/16 in. to 1/2 in.) cable.*

The messenger shall be clamped by two 13 mm (1/2 in.) high carbon steel bolts. The angle hanger shall be mounted with a 16 mm (5/8 in.) through bolt and a 13 mm (1/2 in.) lag screw. The three bolt clamp shall be mounted with a 16 mm (5/8 in.) 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 10 mm (3/8 in.) steel and in accordance with ASTM A 575.*

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

Three bolt clamps shall be a minimum of 150 mm (6 in.) long and 42 mm (1 5/8 in.) wide with three 16 mm (5/8 in.) bolts which shall clamp cable of 8 mm to 13 mm (5/16 to 1/2 in.) 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 32 mm to 57 mm (1 1/4 to 2 1/4 in.) in length and shall hold the size of the cable specified. The sleeves shall be in accordance with ASTM A 659M (ASTM A 659).*

e. Straight Eye-Bolts. *Straight eye-bolts shall be 19 mm (3/4 in.) diameter drop forged steel, a minimum of 356 mm (14 in.) long, and have 150 mm (6 in.) of thread. The steel washers shall be 57 mm (2 1/4 in.) by 57 mm (2 1/4 in.) by 5 mm (3/16 in.) in size with a 21 mm (13/16 in.) 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 19 mm (3/4 in.) mounting bolt and have a full rounded thimble eye for protection of the guy cable.*

(j) Signal Cable.

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

2. 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.*

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

(k) Signal Interconnect.

1. 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.*

2. 6 Pair/19 Telemetry Cable. *6 pair telemetry cable shall contain six 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.*

3. Fiber Optic Interconnect Cable. *Fiber optic cable shall contain six stranded multimode, graded index, optic fibers with a minimum of one 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.

4. 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 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 TS-2 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 FHSS (frequency hopping spread spectrum) 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 RS-232, 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 for 120 v AC operation. The modems shall be rack or shelf mounted in standard NEMA TS-2 type 1 or type 2 cabinets. The modems shall have an operation temperature of -40 to 80°C (-40 to +176°F), 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 GUI, graphical user interface, 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(s) 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 an insertion loss or ≤ 0.1 dB, have an operating frequency in the 900 MHz range, allow throughput energy to be ≤ 220 μJ for 3 kA @ 8/20 μs waveform, have throughput voltage ≤ 144 Vpk, and turn-on voltage shall be ± 600 volts. The unit impedance shall be 50Ω.*

(b) Antennas. *The antenna for the radio modem at the system master/local controllers shall be a single 9 to 12 dB gain Yagi or multiple Yagis, or 6 to 10 dB gain Omni directional antenna to provide a transmission range adequate for communication with all radio modems or repeaters in the system.*

(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.

(l) Detection Wire and Sealant.

*1. **Loop Detector Lead-in Cable.** Runs 700' 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' shall use 14 AWG wire.*

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

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

*3. **Sealant.** Prior to installing roadway loop wire in the roadway saw cuts, the saw cuts shall be cleaned in accordance with the requirements for the joint sealant to be used. After proper cleaning and installation of the loop wire, the saw cut shall be sealed with a joint sealant material in accordance with 906.02(a)1 or 906.02(a)2. The joint sealant material to be used shall be compatible with the roadway materials. The joint sealant material shall be installed in accordance with the applicable sealant specification. However, the joint configuration shall not apply. A copy of the sealant manufacturer's written application instructions shall be submitted to the Engineer prior to any sealant operations. If the Contractor elects to use a sealant complying with 906.02(a)2, the sealant material shall be heated in a kettle or melter constructed as a double boiler with the space between the inner and outer shells filled with oil or other heat-transfer medium. This melter shall have a positive temperature control and a mechanical agitator. A backer rod shall be used for both cold applied sealants and hot poured sealants. The sealant material shall fill the saw cut as shown on the plans. All significant or objectionable surplus joint sealant on the pavement surfaces shall be promptly removed.*

*(m) **Ground Wire.** The ground wire shall be copper wire No. 6, AWG soft-drawn, solid copper in accordance with ASTM B 3.*

*(n) **Splicing Kit.** Splicing kits shall contain a two 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.*

*(o) **Ground Rod and Connections.** Ground rods shall be 13 mm (1/2 in.) in diameter by 2.4 m (8 ft) 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 ohm 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	*668 MPa (97,000 psi)*
Yield strength, 0.2% offset	*58.61 MPa (85,000 psi)*
% of elongation	*90 kPa (13 psi)*

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.

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

(q) Entrance Switch. *The entrance switch shall be a double pole, 50 amp, 120 volt circuit breaker in a NEMA type 3R enclosure. The minimum dimensions of the enclosure shall be: 127 mm (5 in.) wide, 95 mm (3 3/4 in.) deep and 235 mm (9 1/4 in.) height. A 25 mm (1 in.) 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 22 mm (7/8 in.) to 44 mm (1 3/4 in.). 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.

(r) Conduit and Fittings.

1. Steel Conduit. *Steel conduit shall be 50 mm (2 in.) nominal diameter, threaded with a steel coupling on one end meeting applicable requirements for the conduit and the other threaded end protected by a suitable shield. The conduit shall be made of mild steel or intermediate steel. Mild steel conduit shall be in accordance with ANSI C 80.1 and UL 6. Intermediate steel conduit shall be in accordance with UL 1242, ASTM A 513 or ASTM A 135. Conduit shall be hot dipped galvanized on the interior and exterior surfaces in accordance with ANSI C 80.1.*

The various conduit fittings such as bands, elbows, bodies, straps, lock nuts, and threadless connectors, shall be in accordance with Federal Specifications W-F-408. Conduit bends, elbows, and bodies shall be threaded, made of malleable iron, and galvanized. Conduit straps shall be two hole straps with a minimum thickness of 3 mm (1/8 in.) and shall be made of steel which is galvanized in accordance with ANSI C 80.1.

Conduit lock nuts 10 mm to 38 mm (3/8 in. to 1 1/2 in.) in size shall be made of steel. Other sizes shall be made of malleable iron. All nuts shall be galvanized.

2. Polyvinyl Chloride Conduit. *PVC conduit shall be schedule 40 in accordance with ASTM D 1785. The PVC conduit fittings shall be in accordance with ASTM D 2466. Each length of pipe shall include a coupling.*

(s) Detector Housing. *The entire housing casting shall be made from aluminum alloy in accordance with ANSI 320.*

(t) Certification. *Unless otherwise specified, all materials covered herein shall have a type C certification in accordance with 916.*
