SECTION D – SPECIFICATIONS/SCOPE OF WORK

TRAFFIC SIGNAL CONSTRUCTION

A. SCOPE OF WORK

This Contract is for the installation of four Pedestrian Hybrid Beacons (PHB) as shown on the plans. The Contractor shall (within specified tolerances) perform all work in accordance with the lines, grades, typical cross sections, dimensions, and other data shown on the Plans or as modified by written orders including the furnishing of all materials, implements, machinery, equipment, tools, supplies, transportation, labor, and all other things necessary to the satisfactory prosecution and completion of the project in full compliance with the Contract requirements.

B. GENERAL REQUIREMENTS

1. STANDARD SPECIFICATIONS

1.1 Except as otherwise indicated, all work done under this Contract must conform to:

1.1.1 The Maryland State Highway Administration **"Standard Specifications for Construction and Materials"** Dated January 2008.

1.1.2 The Maryland State Highway Administration "**Book of Standards, Highway and Incidental Structures"** Category 8-Traffic including any subsequent revisions, addenda, amendments and/or supplements, and interpretations.

1.1.3 Maryland Manual on Uniform Traffic Control Devices for Streets and Highways- 2011 Edition.

1.1.4 National Electrical Manufactures Association (NEMA) TS - 2-2003 Standards Publication, and latest amendments or revisions.

1.1.5 Montgomery County Department of Transportation Design Standards.

Hereinafter, these documents will be referred to as the **"Standard Specifications/Scope of Work"** and are hereby incorporated by reference into this Contract. Additionally, the work must also conform to the Special Provisions Section, some of which are those of the Maryland State Highway Administration and Federal Aid Construction Contracts. All rights and payment therein that were assigned to the State of Maryland, must apply to Montgomery County, Maryland. All reference to departments, bureaus, offices, agencies or activities of the State of Maryland, must apply instead to the similar activity of Montgomery County. In case of conflict between the Standard Specifications, and any provision of this Contract, the Contract must govern. However, the Bidder or Contractor should request interpretation from the Engineer.

2. CODES AND LAWS

2.1 All work must be in accordance with the National Electrical Code, National Electrical Safety Code, Miss Utility regulations and to State and local laws and ordinances governing such work and to the rules and regulations of the electric utility serving the facility.

3. WORKMANSHIP AND LICENSE REQUIREMENT

3.1 The Contractor must perform all work to a high degree of workmanship. Items such as improperly set couplings, unreamed conduit ends, and concrete or masonry work that are not up to the standard specifically required by the Contract must be removed and replaced at no cost to the County.

3.2 During the final inspection of each unit of work, should it be found that non-concealed work is substandard; the burden of proof that the concealed work is up to the required standard is upon the Contractor. The Contractor may be required to do whatever is necessary, including exposing the concealed work, to clearly establish that the concealed work meets the specifications, at no cost to the County.

3.3 A Master Electrician's License issued by the State of Maryland.is required in order to perform electrical work in Montgomery and to ensure workmanship applied to installation of the electrical components of traffic signal and ATMS work.

4. CONTRACTOR QUALIFICATIONS, EQUIPMENT AND REFERENCE

4.1 The Contractor's firm must have a minimum of seven (7) years of acceptable experience in substantial traffic signal construction work with state or local governments in Maryland or in the greater Metropolitan Washington D.C. Virginia region.

4.2 All work performed under this contract must be performed by Contractor personal possessing the following licenses and certifications:

4.2.1 Traffic Signal Technician IMSA Level II certification for any work within the traffic signal cabinet.

4.3 Submit copies of Certifications required under section 4.2.1 with your bid (See also Mandatory Submissions listed on Bid Cover Sheet and Attachment F Reference Documentation

5. UTILITIES

5.1 Utilities are shown on the plans to the extent that they can be, based upon records and surface field indications. All utility locations will require field verification in cooperation with the affected utility companies. The CONTRACTOR must follow the guidelines and procedures set forth in the Professional Excavator’s Manual and maintain responsibility for locating all gas, electric, and sewer

laterals, valve boxes, manholes, etc., and ensuring that they are properly protected and that signal equipment locations are adjusted accordingly, with approval from the ENGINEER. Should the Contractor in the course of operations encounter any underground or overhead utilities, the presence of which were not previously known, must immediately notify the Engineer, and take all necessary precautions to protect the utilities and maintain continuance of service until said utilities can be relocated by the owners.

5.2 In case of any damage to utilities by the Contractor, either above or below ground, the Contractor must restore such utilities to a condition equal to that which existed before the damage was done, by repairing, rebuilding, or otherwise restoring as may be directed, and at the Contractor's entire cost and expense.

5.3 The Contractor must take into consideration when preparing his bid, any relocation or installation by the utility companies which may be necessary in areas within, or adjacent to, the limits of this Contract. No additional compensation will be allowed the Contractor for work interruptions, changes in construction sequences, changes in methods of handling. excavation and drainage, and changes in types of equipment used, made necessary by others performing work within, or adjacent to, the limits of this Contract. The number of working days as stated in this Contract includes working days needed for utility adjustments and no extension of time will be granted for delays caused by utility adjustments.

5.4 All expenses likely to be incurred by the Contractor as a result of working around and protecting utilities, as well as cooperating with the owners of the same during the relocating of such facilities, will not be measured or compensated for under any stipulated pay item. All associated costs and delays to the Contractor must be included in the Contract unit prices bid for other items.

5.5 The following list, but not limited to, of the utility companies serving in the area within the limits of the Contract. It must be the Contractor's responsibility to notify these utilities and coordinate his construction operations with them to avoid unnecessary delays.

- Washington Gas Light Company
- Potomac Electric Power Company
- Baltimore Gas Electric Company
- Allegheny Power
- Potomac Edison Power Company
- Washington Suburban Sanitary Commission
- Verizon Telephone Company
- Cable TV Montgomery, Inc.
- RCN
- MCI
- MFS Network Services

FOR LOCATIONS OF UTILITIES CALL “MISS UTILITY” 1-800-257-7777

24 HOURS A DAY 48 HOURS IN ADVANCE OF ANY WORK.

FOR LOCATIONS OF EXISTING TRAFFIC SIGNAL EQUIPMENT, CALL MONTGOMERY COUNTY’S TRANSPORTATION MANAGEMENT SECTION AT 240-777-2100, 48 HOURS IN ADVANCE OF ANY WORK.

C. TRAFFIC SIGNAL WORK

The Contractor's responsibility regarding Traffic Signal installation work shall consist of the following items:

1.0 Furnish and/or install signal equipment including: controller cabinets, controller foundations, signal structures and foundations, pedestal poles and foundations, conduits, wiring, hand boxes, signal head assemblies, video detector units, conductors, concrete, reinforcing steel, forms for structure foundations, signs, miscellaneous nuts, bolts, and washers, and all other miscellaneous equipment that is required to complete the project, including all necessary barricades or devices required to maintain proper traffic control in accordance with the Maryland Manual on Uniform Traffic Control Devices (MDMUTCD).

2.0 Furnish and install Econolite NEMA size5 and NEMA size 6 controller cabinets with controllers as shown on the plans, and complete cabinet signal components, including conflict monitors, load switches, relays, flashers, and detector amplifiers configured to the Montgomery County cabinet requirement. The contractor shall ship the signal cabinet to Montgomery County signal shop to be set up and tested before installing the cabinet in the field. The contractor is responsible for transporting and installing the signal cabinet in the field.

3.0 The locations of traffic signal pole foundations, controllers, pedestal poles, conduit, ground boxes, etc., shown on the plans are approximate. The Contractor shall give the County Engineer 48 hours’ notice of his/her intention to establish the final location of any foundations, pedestal poles, conduit, etc., and have the locations staked on the ground with the presence of County Engineer.

4.0 The plans are drawn approximately to scale, the positional relationship of some system components and equipment (e.g., cabinet and pole locations) may be necessary to adjust due to field conditions. NO EXTRA COMPENSATION WILL BE GRANTED FOR FULFILLING THE REQUIREMENTS STATED ABOVE.

5.0 The Contractor is responsible to furnish all materials necessary to complete the traffic signal installation, whether the item is specifically mentioned or not. All unspecified materials (i.e., electrical tape, bolts, and nuts, etc.,) shall meet the

requirements of the National Electrical Code. All materials supplied by the Contractor shall be new, undepreciated stock.

6.0 All materials furnished by the Contractor shall become the property of the County, effective upon successful completion of a thirty-day test period. The Contractor shall have full responsibility for the material until the date of acceptance with respect to damage, theft, or loss.

7.0 Prior to final acceptance by the County, the Contractor is responsible for removal, replacement, and reinstallation of any damaged material at the Contractor's expense.

8.0 Each signal head shall be a weather tight assembly of one or more signal faces of the expansible, adjustable, LED type, together with all brackets and fittings necessary for proper mounting with the type of signal support designated on the plans. Each signal face shall consist of one or more signal sections, rigidly and securely fastened together, capable of being positively positioned to control the movement of one direction of traffic. Each signal section shall consist of an optical unit, housing, housing door, and visor. All signal heads on a project shall be the product of one manufacturer and conform to MSHA or County standards and specifications provided in these documents.

8.1 The housing for each signal section shall be made of durable polycarbonate and shall be black in color. It shall be clean, smooth and free from flaws, cracks, blowholes, and other imperfections. It shall be designated as a self-contained unit capable of separate mounting or inclusion in a signal face containing two or more signal sections rigidly fastened and perfectly aligned together. It shall be equipped with round openings in the top and bottom so that it may be rotated between waterproof supporting brackets and thus be capable of being directed at any angle in the horizontal plane. It shall be equipped with positive locking devices to maintain a specific angle of direction when in place.

8.2 The doors shall be black in color, and suitably hinged and held securely to the body of the housing by simple stainless steel locking devices. All other door parts, such as hinge pins, lens clips, screws, etc., shall also be of stainless steel material. Neoprene gasketing shall be used between the lenses and reflectors to exclude dust and moisture.

8.3 The depth of each housing section shall not be greater than 7- 1/8" for 12-inch signal heads. Each signal housing shall accept both plastic and aluminum backplates.

8.4 All visors shall be made of durable polycarbonate and shall form a tunnel visor. All visors shall be black in color, not less than 0.05 inches in thickness. Each visor shall be designed to fit tightly against the housing door. Visors shall be at least 9-1/2 inches deep for 12-inch signal sections, and have flat black finish on the inside surface. All visors supporting louvers shall be full circle and constructed of aluminum and have the same physical appearance as the polycarbonate visors.

8.5 The optical system for each signal section shall be designed for use in standard 12" traffic signal section.

8.6 The lens shall be a LED unit, and shall conform to ITE requirements set forth in the most recent, formally-adopted version of the specification titled "Vehicle Traffic Control Signal heads - Chapter 2: Light Emitting Diode (LED) Vehicle Signal Modules," "Vehicle Traffic Control Signal Heads-Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules" and "Pedestrian Traffic Control Signal Indications- Part 2 Light Emitting Diode (LED) Pedestrian Traffic Signal Modules," by the Institute of Transportation Engineers (I.T.E.), Washington, D.C.

8.7 All lenses shall be standard clear lenses, MG-Type 1 "A" lamps, 120 VAC Power.

8.8 Reflectors shall be either aluminum or Alzak treated polycarbonate.

8.9 Lamp sockets shall be standard pre-focused rotatable socket with lamp grip to permit positioning of the lamp filament for optimum output without the use of tools. Lamp sockets shall be provided with two color-coded leads and pronged terminals. The lead wires shall be #18 AWG, type THW, rated for a maximum of 600 volts, and capable of withstanding temperatures up to 110 degrees Centigrade. The lead wires shall have 1/32-inch thermoplastic insulation.

8.10 Each pedestrian signal head must meet the following requirements:

8.10.1 The maximum dimensions of the signal head shall be: 18 ½ inches wide 18 3/4 inches high 9 inches deep

8.10.2 The casing of the signal head shall be one piece polycarbonate or corrosion resistant aluminum alloy with four (4) integrally cast hinges to provide for operation of a swing open door and thumb screw locking device. The casing shall be black in color.

8.10.3 The entire signal head assembly shall form a dust and weatherproof unit after installation. 2.3.4 Each signal head shall be compatible with the mounting hardware as stated in these specifications. 2

8.10.4 The optical unit shall include 14" Dual LED lens, Portland Orange/White, AllnGaP & InGaN LED Type, 80-135 (VAC) input voltage, designed to display a uniform, bright alternate International Symbol Hand & Walking Man.

8.10.5 Each pedestrian head shall include a 1-1/2" deep polycarbonate eggcrate visor with impregnated flat back color, designed to eliminate the interference of sunlight and to allow clear visibility of the messages.

8.10.6 Each pedestrian signal door shall be designed with adequate hinges and latch slots to provide swing open door operation and thumb screw locking devices.

8.10.7 All associated pins, screws, bolts, and nuts shall be made of stainless-steel material to resist corrosion.

8.10.8 Mounting Hardware Each mounting hardware assembly shall be a universally adjustable signal bracket, meeting the following requirements listed below.

8.10.9 The bracket shall allow for traffic or pedestrian signal head rotation about the bracket axis, rotation about the supporting member axis, rotation on the vertical plane, and sliding of the support tube against the

bracket connection point on the supporting member.

8.10.10 The bracket shall be attached to the supporting member with a stainless steel band or cable capable of withstanding 100 KSI tensile stress.

8.10.11 The bracket attachment to the signal head shall assume rigid connection through the top and the bottom of the signal head.

8.10.12 The bracket shall be of the type to accept the number of signal sections specified in the plans for each signal head, (i.e., one-way brackets shall be provided for a single pedestrian head and two-way brackets for two pedestrian heads).

8.10.13 The entire assembly shall be capable of securely supporting a signal head under 80 mph wind loading conditions on the attached member.

8.10.14 All parts used in this assembly shall be made of corrosion resistant material or be coated with a corrosion resistant finish.

8.10.15 Each bracket shall be furnished with the necessary hardware for installation on the signal supporting member.

8.10.16 When two-way mounting brackets are used, the design (arm lengths, the distance between the upper and lower arms, and the angle between the two-way arms) shall be such as to allow complete rotation of the pedestrian signal heads about their vertical axis.

8.10.17 All pedestrian signals shall be furnished with the specified mounting hardware installed and completely wired to the signal head, suitable for mounting on the specified side of the pole. The casing shall include top and bottom openings that are sealed with removable plugs and that are intended for use with 1-1/2 inch pipe bracket mounting hardware. 2

8.10.18 Other brands of traffic and pedestrian signal mounting hardware, installed and completely wired to the signal head, shall be suitable for mounting on the specified side of the pole. The casing shall include top and bottom openings that are sealed with removable plugs and that are intended for use with 1-1/2 inch pipe bracket mounting hardware.

8.10.19 Pedestrian Pushbutton assembly shall be one piece cast aluminum construction which includes a pushbutton switch with an “ADA” 2-inch die cast aluminum button, sign frame, and sign.

8.10.20 The housing of the pushbutton switch shall be completely dust and moisture resistant.

8.10.21 The sign frame for each assembly shall accept a minimum 5" x 7" sign.

8.10.22 The sign shall have a white reflective background with black lettering and border meeting graphical and textural requirements as specified on the plans.

8.10.23 Curved back assemblies shall be provided for mounting on round poles of 4 to 15 inches in diameter.

8.10.24 The pushbutton housing and sign shall have a federal yellow, corrosion resistant finish.

8.10.25 All signs shall have black directional arrows, indicating direction of movement associated with the pushbuttons, and conform to the PUSH

BUTTON FOR GREEN LIGHT Sign (R10-3b) contained in the MDMUTCD

8.10.26 Traffic Signal Structures, signal structure poles, signal mast arms, shall meet the Maryland State Highway Administration "Standard Specifications for Construction and Materials" Dated January 2008

8.10.27 All foundations shall be built in accordance with the requirements stated in The Maryland State Highway Administration "Book of Standards, Highway and Incidental Structures" Standard No. MD801.

8.10.28 The Contractor shall furnish eight-phase traffic signal controllers complying with current NEMA specifications and compatible with the existing County signal system, complete with cabinet, solid state flasher, conflict monitors, amplifiers, solid state load switches, solid state loop detector modifiers, pictorial layout of components and all other related components as described in the signal plans.

8.10.29 The Contractor shall supply and install 200AMP, 120/240V, single phase, 3 wire electrical service pedestal confirming to Maryland State Highway Administration "Book of Standards, Highway and Incidental Structures" Standard No. MD807.07.

8.10.30The contractor shall install all necessary wiring from meter pedestal to the signal cabinet and install conduit to power source as shown in the plans.

8.10.31 The Contractor shall furnish and install underground conduit facilities as indicated in the plans.

8.10.32 Unless otherwise shown on the plans or standard detail sheets, all conductors shall be placed in schedule 80 PVC conduit except when in metal poles.

8.10.33 Conduit and fittings shall be of the sizes and types shown on the plans. Each section of conduit shall bear evidence of approval by Underwriter's Laboratories.

8.10.34 Conduit terminating in posts or pedestal bases shall not extend vertically more than 3 inches above the concrete foundation. Field bends of conduit shall have a minimum radius of 12 diameters of the nominal size of conduit. c. PVC conduit shall be joined by the solvent-weld method in accordance with the conduit manufacturer's recommendations. No reducer couplings shall be used unless specifically indicated on the plans.

8.10.35 Conduit and fittings shall have burrs and rough places smoothed and shall be clean and free of obstructions before cable is installed. Field cuts shall be made with a hacksaw only and shall be square and true so that the ends will butt or come together for the full diameter thereof. In no case shall a cutting torch be used to cut or join conduit. When a standard coupling cannot be used, an approved union coupling shall be used and shall provide a watertight coupling between the conduits. All couplings shall be properly installed to bring their ends of connected conduit together to produce a good rigid connection throughout the entire length of the conduit run. Ends of conduit shall be capped or plugged until installation of wire is complete.

8.10.36 Conduits shall be placed in an open trench at a minimum 24 inches depth below the curb grade in the sidewalk areas, or 24 inches below the finished street grade in the street areas. Where specified in plans, conduits shall be installed at greater depths.

8.10.37 The Contractor shall coordinate conduit placement activities with the County Engineer before beginning work.

8.10.38 Ditchlines within paving areas and within two feet back of curb are to be mechanically tamped. All tamping is to be density controlled to 90% standard proctor density at optimum moisture content and no greater than 5% optimum or less than 2% below optimum.

8.10.39 Backfill material is to be select native material, 6" diameter clods and smaller. It is permissible to put backfill in 6"-8" lifts with densities being taken for each 1' of compacted material - on offsetting stations of 50'. h. The Contractor shall provide adequately bent conduit and shall properly excavate so as to prevent damage to the conduit or conductor by a bend radius which is too short.

8.10.40 Conduit runs shall be continuous and of the same material (metal only or PVC only). Where tying into existing conduit, the Contractor must continue with the same material (metal to metal or PVC to PVC).

8.10.41 Conduit must be continuous, reasonably dry, completely free of debris, and without sharp projections, edges, or short bends.

8.10.42 Weather heads shall be of aluminum and threaded to conduit.

8.10.43 Cables for intersection signalization shall be multi-conductor capable of operating at 600 volts maximum, and suitable for use at conductor temperatures not exceeding 75 degrees Centigrade (167 degrees F).

8.10.44 Conductors shall be stranded IMSA 19-1, #14 AWG copper wire. The copper wire (before insulating) shall meet requirements of the latest American Society for Testing Materials' (ASTM) standards for uncoated

8.10.45 Where practical, color codes shall be followed so that the red insulated conductor connects to the red signal indication terminal, yellow to yellow, and green to green. This color code shall be followed throughout the cable run, not just at the points of termination.

8.10.46 Power lead-in cable shall be stranded THW copper wire and suitable for AC service. The cable shall be capable of operating at 600 volts maximum and suitable for use at conductor temperatures not exceeding 75 degrees C. Material and construction shall be in accordance with the applicable requirements of IMSA standards.

8.10.47 Conductors shall be stranded, anneal coated copper. Copper wire, before insulating or stranding, shall meet the requirements of the latest edition of ASTM Special Provisions for Traffic Signal Installations Page 9 of 21 Aug-07 B-033 (for coated wire). Stranding shall be class B, in accordance with the latest edition of ASTM B-8.

8.10.48 Insulation shall consist of cross-linked thermosetting polyethylene, meeting the requirements of IMSA and listed by UL as type USE RHW-75C

8.10.49 The conductors shall be installed in a manner so as to insure against harmful stretching of the conductors or damage to the insulation.

Installation methods shall conform to the recommendations of the cable manufacturer.

8.10.50 All cables in a given conduit run shall be pulled at the same time and the conductors shall be assembled to form one loop in such a manner that the pulling tension is equally distributed to all the cables. Long, hard pulls will necessitate the use of pulling eyes. For short runs, the cables may be gripped directly by the conductors by forming them into a loop to which the pull wire or rope can be attached. The insulation on each conductor shall be removed before the loop is formed. The method used will depend on the anticipated maximum pulling tension in each case.

8.10.51 The manufacturer's recommended maximum pulling tensions shall not be exceeded under any circumstances.

8.10.52 All wire and cable shall conform to the requirements shown on the plans, except wire and cable specifically covered by other items of this contract.

8.10.53 Controller Cabinet Wiring shall consist of connecting (1) signal wires, (2) power wires, (3) ground wires, (4) pedestrian pushbutton wires,

8.10.54In the controller cabinet, stranded signal conductors from the field shall be stripped back and a solderless terminal connector shall be attached by means of a compression crimp insulated ring lug. These terminal connectors shall be inserted under the binder head screw and tightened securely.

8.10.55Other wiring for the controller shall be completed as shown on the wiring diagrams and in the instructions furnished with the controller by the manufacturer.

8.10.56 All field wiring in cabinets shall be neatly installed. Incoming cables shall be trained to their destination and neatly laced together. All spare wires shall be trimmed and neatly coiled with their ends taped.

8.10.57 Pedestrian pushbuttons shall have a logic ground wire that is completely isolated and independent from all other ground wires. This wire shall be connected to the designated terminal in the controller cabinet.

8.10.58 The Contractor shall wire all signal heads with adequate wire to tie each head into the signal cable for the system. Wiring for the signal head shall consist of connecting the terminal block in each signal section to the common terminal block in each signal face, and where applicable, connecting the common terminal block in each signal face to the terminal block in the signal-head terminal compartment.

8.10.59 For mast arm and pole mounted heads, conductors running from the pole's terminal compartment or transformer base to the signal head terminal shall be #14 AWG stranded.

8.10.60 Splices are prohibited, unless approved by County Engineer.

8.10.61 Terminal blocks shall be utilized where possible when terminating signal cables in signal pole bases.

8.10.62 Splicing methods shall be in accordance with good electrical practice and the cable manufacturer's recommendations.

8.10.63 All materials used shall be of high quality and specifically intended for this purpose. Cables shall be trained to their final position and cut to proper lengths.

8.10.64 The cable's jacket and insulation shall be removed as required. In doing this, use proper care to insure against nicking the conductors.

D. TRAFFIC SIGNAL STRUCTURES

1. This work consists of furnishing and installing MSHA standard galvanized traffic signal mast arms, mast arm poles, pedestal poles and transformer bases as specified in the traffic Signal plans or as directed by the Engineer.
2. Design must meet the 1994 edition of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals except as noted. All welding must conform to American Welding Society (AWS) Structural Welding Code D1.1 - Steel, Tubular Structures. Each mast arm(s) and mast arm pole structure furnished must consist of a design from a steel pole shaft with a steel base plate and flange plate, steel mast arm shaft(s) with steel flange plate(s), four flange bolts per mast arm, four anchor bolts and miscellaneous hardware.
3. The mast arms and mast arm poles must be manufactured from steel tubing conforming to A 595 Grade A or equal. Each mast arm and mast arm pole must be fabricated of one length and must have one longitudinal weld, parallel to the long axis of the mast arm or mast arm pole, with no transverse welds. The longitudinal weld must be finished to form a smooth outside surface and the wall of the mast arms and mast arm poles must be of uniform thickness including the welded area. The mast arms and mast arm poles must be round or multi-sided (8 sides or more) in cross section and be uniformly tapered from butt to tip with a 1 in. reduction in diameter for each 7 ft in length (0.14 in./ ft). Mast arms must be of two piece design for all mast arms 50 ft and 60 ft in length. Mast arms must be of three-piece design for all mast arms 70 ft in length. Any combination of two piece of 50 ft and 60 ft arms of the same butt diameter must fit together and any combination of two or three piece of 60 ft and 70 ft mast arms in sequence must fit together. The bolted splice for two- or three-piece mast arms must be as specified in the Contract Document.
4. 50 ft mast arms must have a butt section 30 ft in length.
5. 60 ft and 70 ft mast arms must have a butt section of 35 ft in length.
6. 38 ft single piece mast arms must be 9 in. outside diameter at the flange plate and must be made of 7-gauge (0.179 in.) thickness steel.
7. 50 ft two piece mast arm butt sections must be 10 in. outside diameter at the flange plate and must be made of 3 gauge (0.250 in.) thickness steel.
8. 60 ft two piece and 70 ft three-piece mast arm butt sections must be 12.5 in. outside diameter at the flange plate and must be made of 3 gauge (0. 250 in.) thickness steel.
9. All extension sections of two- and three-piece mast arms must be made of 7-gauge (0.179 in.) thickness steel.

10. Single 27 ft mast arm pole designed with a 38 ft mast arm length must be 12 in. outside diameter at the base plate and must be made of 7-gauge (0.179 in.) thickness steel.
11. Single 27 ft mast arm pole designed with a 50 ft mast arm length must be 13 in. outside diameter at the base plate and must be made of 3-gauge (0.250 in.) thickness steel.
12. Single 27 ft mast arm pole designed with 60 ft or 70 ft mast arm lengths must be 15 in. outside diameter at the base plate and must be made of zero-gauge (0.312 in.) thickness steel.
13. The material for mast arm pole base plate must conform to A 709, Grade 36 and must be of sufficient size and strength. The base plate must be secured to the lower end of the mast arm pole by two continuous electric arc welds. The base plate must telescope the mast arm pole with one weld on the inside of the base plate at the end of the mast arm pole shaft. The remaining weld must be located on the outside of the base plate, around the circumference of the mast arm pole. The weld connection must develop the full strength of the adjacent mast arm pole shaft to resist bending action. All base plates must be fabricated with the holes for anchor bolts to the size and location dimensions as shown on the appropriate detail.
14. All mast arms and mast arm poles must be furnished with flange plate(s) as noted in the details. These attachments, including the bolts, must be connected in such a manner as to develop the minimum guaranteed yield and ultimate tensile strength for the mast arm and mast arm pole. This assembly must be capable of transferring the maximum moment being carried by the mast arm without distortion or rotation of the mast arm or the attachment. Flange plate(s) must be connected by the use of 4 bolts. The size of the plates and bolts must be as shown in the details. Four (1-1/2 in. O.D.) rubber grommets must be furnished for each mast arm to accommodate signal heads wiring access.
15. The mast arm flange plate must be secured to the lower end of the mast arm pole by two continuous electric arc welds. The mast arm flange plate must telescope the mast arm with one weld located on the inside of the flange plate at the end of the mast arm. The remaining weld must be located on the outside surface of the flange plate around the circumference of the mast arm pole. The weld connections must develop the full strength of the adjacent mast arm to resist bending action.
16. Mast arm flange plates and mast arm pole flange plates surfaces must be plane to within 1/16 in. and must be free of any buildup of galvanizing (drips, runs, etc.) which would prevent intimate contact between the connecting surfaces.
17. Access hole frames must be welded into the mast arm pole as detailed in MD 818.11. A galvanized steel cover, conforming to A709, Grade 36 must cover the access hole frame. The access hole cover's top must be secured to the access hole frame by a hinge fabricated from 0.063 in. stainless steel using a 0.120 in. diameter stainless steel hinge pin. The hinge must be secured to the access hole frame by 2 1/4 in. 20 UNC) head stainless steel bolts. The hinge must be secured to the access hole cover by 2 (1/4 in. 20 UNC) hex head stainless steel bolts and lock nuts. A slotted opening must be provided at the bottom of the access hole

cover to allow for attachment of a furnished (1/4 in. 20 UNC) hex head stainless steel bolt into the access hole frame face.

18. A 3/8 in. diameter X 1 in. stud copper servit post for two #6 AWG stranded wire must be furnished into the bottom of the access hole frame.
19. Mast arm poles must be provided with entrance ways for cable as noted on the appropriate detail. These holes must be factory drilled and a straight tapped coupling, conforming to Underwriters Laboratory's UL 6 Specification, for 3 in. rigid conduits, must be installed for each hole. A nipple with a unitized hexagonal fitting and integral inside radius on one end must then be installed and fully seated on the interior side of the coupling. Location and installation of the coupling must be as shown in the details.
20. "J" hooks must be installed as follows, located 1 ft above the highest mast arm T dimension.
21. A single "J" hook must be welded inside the pole for single mast arm poles. Two "J" hooks must be welded inside the pole for twin mast arm poles and triple mast arm poles.
22. All mast arms, mast arm poles, access hole frames and hardware, except materials manufactured from stainless steel or cast aluminum, must be hot dipped galvanized. The galvanized coating must conform to the thickness, adherence, and quality requirements of A123 or A153 for hardware. Threaded components must be chased and cleaned after galvanizing. All internally threaded components must be tapped the minimum amount required to permit assembly on the coated externally threaded fastener. Internally threaded components must be provided with a lubricant which must be clean and dry to the touch.
23. Each mast arm pole must be furnished with four removable ornamental anchor bolt covers made of cast aluminum. Bolt holes for attaching the bolt covers to the base plate must be drilled at the location obtained by following the diagonal line of the base plate until it intersects the bolt circle diameter, then proceeding tangentially from the bolt circle diameter a distance equal to the Anchor Bolt Center to Bolt Slot Center Distance as provided in the MD 818.14. Attachment to the base must be made using hex head stainless steel bolts (1/4 in.- 20 UNC).
24. Each mast arm extension section and mast arm pole must be furnished with a removable domed cap, fabricated from cast aluminum, circumferentially attached to the outside of the pole shaft or mast arm end with 3 hex head stainless steel bolts (1/4 in.- 20 UNC). All mast arm caps must have inside diameter one in. Larger than the outside diameter of mast arm end.
25. Each mast arm and mast arm pole must have an identification plate mechanically attached, oriented such that the identification plate may be read from a ground observation position.
26. Single piece mast arms and the butt section of two and three piece mast arms must have the identification plate attached 6 in. above the flange plate.
27. Each extension section of two- and three-piece mast arms must have the identification plate attached 6 in. from the larger diameter end.
28. Poles must have the identification plate attached 6 in. above the bottom flange plate.
29. Recessed hub type galvanized malleable iron plugs must be inserted flush into all mast arm pole couplings.

30. Each mast arm pole anchor bolt must be made of steel in accordance with F1554, Grade 55S1.
31. Anchor bolt threads must be of cut thread design with a minimum 9 in. of threads at the top and bottom.
32. The template and anchor plates must be as shown the contract documents
33. The diameter of the anchor bolt must be stamped into the top of the threaded end of each anchor bolt.
34. Each anchor bolt must be provided with two anchor bolt nuts and two flat washers.
35. Anchor bolt nuts must conform to A 194 grade 2 or 2H or A 563 D or DH.
36. All nuts must be tapped oversize the minimum amount required to permit
37. assembly on the coated externally threaded fastener.
38. Washers must conform to F436.
39. All nuts, washers and the top 12 in. of all anchor bolts must be hot dipped or mechanically galvanized.
40. The galvanized coating must conform to the thickness, adherence and quality requirements of A 123 or A 153 for hardware.
41. All high strength bolts (of a given length), nuts (of a given size) and washers (of a given diameter) must be from the same manufacturing lot per each requisition of materials. The use of foreign made fasteners is prohibited! Alternate Design. Alternate mast arm and mast arm pole designs will be considered provided the following qualifications are observed:
42. Alternate mast arm designs may use sectional construction provided each section has a minimum length of 30 ft except for the outermost section. Overlap between sections must be minimum 18 in. Bolt circle diameters must be as specified in the Contract Document.
43. Alternate post designs may be straight (not tapered) sections and must have a base diameter equal to, or no greater than 1 in. more than, those values shown on the typicals.
44. All alternate design must be structurally equivalent to the original design and as approved by the Engineer.
45. Each pedestal pole's height must be determined by the total height of the pedestal pole including the transformer base.
46. 10 ft pole height must consist of a 103 in. steel shaft with a steel base plate plus a 17 in. transformer base.
47. 14 ft pole height must consist of a 151 in. steel shaft with a steel base plate plus a17 in. transformer base.
48. 20 ft pole height must consist of a 240 in. steel shaft with a steel base plate plus a17 in. transformer base.
49. Each pedestal pole furnished must consist of a design from a steel shaft with a steel base plate, transformer base and all miscellaneous hardware.
50. The pedestal pole shaft must be fabricated of one length and must have one longitudinal weld, parallel to the long axis of the pedestal pole shaft, with no transverse welds. The longitudinal weld must be finished to form a smooth outside surface and the wall of the pedestal pole shaft must be uniform in thickness including the welded area. The pedestal pole shaft must be round or multi-sided (less than eight sides not acceptable) in cross section. 14 ft units must

be uniformly tapered from butt to tip with a 1 in. reduction in diameter for each 7 ft in length (0.14 in./ ft). 10 ft unit must not be tapered.

51. 10 ft pedestal pole shaft must be 4 1/2 in. outside diameter, Schedule 40 pipe, and conform to A 501.
52. The base plate material must meet the requirements of A 709, Grade 36. The base plate must be secured to the lower end of the pedestal pole shaft by two continuous electric arc welds. The base plate must telescope the pedestal pole shaft with one weld on the inside of the base plate at the end of the pedestal pole shaft. The remaining weld must be located on the outside of the base plate at the top of the pedestal pole shaft. The weld connection must develop the full strength of the adjacent pedestal pole shaft to resist bending action. All bases plate must be fabricated with the holes for anchor bolts to the size and location dimensions as shown in MD-818.16 and 818.17.
53. All pedestal poles and hardware, except materials manufactured from stainless steel or cast aluminum, must be hot dipped galvanized. The galvanized coating must conform to the thickness, adherence and quality requirements of A 123 and A 153 for hardware. Threaded components must be chased and cleaned after galvanizing. All internally threaded components must be tapped oversize the minimum amount required to permit assembly on the coated externally threaded fastener. Internally threaded components must be provided with a lubricant which must be clean and dry to the touch.
54. Each pedestal pole must be furnished with a removable domed cap, fabricated from cast aluminum, circumferentially attached to the side of the pole with three hex head type 304 stainless steel bolts (1/4 in. 20 UNC).
55. Each pedestal pole must have an identification plate mechanically attached 6 in. above the pedestal pole base plate and oriented so that the identification plate may be read from a ground observation position.
56. Recessed hub type galvanized malleable iron plugs must be inserted flush into all couplings.
57. All transformer bases must be approved by FHWA as meeting breakaway under NCHRP 350
58. Each transformer base must be furnished with four hex head bolts, four hex head nuts and all associated hardware as shown on the appropriate detail for fastening the pedestal pole base plate to the top of the transformer base. All bolts must conform to A 325 specifications and must be galvanized.
59. Each pedestal pole anchor bolt must be made of steel conforming to M 314, Grade 55 S1.
60. Anchor bolt threads must be of cut thread design with a minimum 6 in. of threads at the top.
61. The template and anchor plates must be as shown on MD801.01.
62. The diameter of the anchor bolt must be stamped into the top of the threaded end of each anchor bolt.
63. Each anchor bolt must be provided with two attached heavy hex nuts and two attached flat washers.
64. Anchor bolt nuts must conform to A 194, grade 2 or 2H, or A 563, D or DH.
65. All nuts must be tapped oversize the minimum amount required to permit assembly on the coated externally threaded fastener.

66. Washers must conform to F 436.
67. All nuts, washers, and the top 12 in. of all anchor bolts must be hot dipped or mechanically galvanized. The galvanized coating must conform to the thickness, adherence and quality requirements of A 123 or A 153 for hardware.
68. All high strength bolts (of a given length), nuts (of a given size) and washers (of a given diameter) must be from the same manufacturing lot per each requisition of materials. The use of foreign made fasteners is prohibited.

E. Traffic Signal Controller Assembly

1.0 The controller assembly (CA), as defined by NEMA TS2-1.1.7. as being a complete electrical unit, must 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.

2.0 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

2.1 The Controller Unit must be compact in design so as to fit in limited cabinet space, and must be capable of being shelf mounted.
2.2 The Controller Unit must be modular in design. Circuit boards must be vertically mounted with card guides both top and bottom. Alternatively, the circuit boards may be mounted on standoffs. The enclosure must be designed for easy access during maintenance. It must be permissible to accomplish this with the use of extender boards or cables. If extender boards or cables are required for maintenance of the Controller Unit 2 sets must be supplied with every 10 (ten) Controller Units Purchased.
2.3 The enclosure must be constructed of sheet steel or aluminum and must be finished with an attractive and durable protective coating. Model, serial number, and date of manufacture must be permanently displayed on the top outside surface.
2.4 All circuit boards must meet the NEMA Standard set forth in NEMA LI-1-989, plus the following requirements.
2.4.1 All plated through holes and exposed circuit traces must be plated with solder.
2.4.2 A solder mask must cover both sides of the printed circuit board. The circuit reference designation for all components and the polarity of all capacitors and diodes must be clearly marked adjacent to the component. Pin 1 of all integrated circuit packages must be designated on both sides of all circuit boards. If the designations are silk screened, epoxy-based ink must be used.

2.4.3 Both sides of all circuit boards must be coated with a clear moisture-proof and fungus-proof coating.

2.4.4 All electrical mating surfaces must be gold platted.

2.4.5 13.3.5.6 The front of the Controller Unit must consist of a panel(s) for display, keyboard, fuse-holders and connectors. The panel(s) must be removable for maintenance and will require only simple hand tools to remove. Alternatively, the front panel may function as a door to allow access to the circuit boards.

2.4.6 The display must be liquid crystal in design. The display must be back-lighted for ease of viewing with multiple levels of contrast adjustment. The display must be alphanumeric with at least 8 lines by 40 characters line and must show program and status information. The display area must have a minimum measurement of 1 1/2 inches high by 4 1/2 inches wide. 1 1/2" x 4 1/2" (H&W)

2.4.7 A telephone type keyboard must be used for manual entry of timing values and to request display of dynamic timing conditions. The following characteristics must be required:

2.4.8 The keyboard must be clearly labeled with environmentally sealed keys. Keys and keyboard must be large enough to allow the operator to access the Controller Unit while wearing gloves.

2.4.9 Arrow keys must be used to move the cursor. Letter keys must not be used for this function. Multiple use of the arrow keys must not be acceptable.

2.4.10 Verification - The keyboard must provide a "tactile" indication of contact when depressed. A "load check" status indicator or the display must blink once to indicate timing parameters have been loaded into memory. An audible feedback to indicate that a key press has been registered is desirable, but not a requirement of this specification. An audible keypad function may be supplied. Means must be provided to toggle this function ON/OFF and control volume level.

2.4.11 The following interface connectors must be accessible from the front of the controller:

2.4.12 Type 1 Controller Unit only: Connector A must mate with MS3106 ( )-18-1S

2.4.13 Type 2 Controller Unit only: Connector A must mate with MS3116( )-22-55S

2.4.14 Type 2 Controller Unit only: Connector B must mate with MS3116( )-22-55P

2.4.15 Type 2 Controller Unit only: Connector C must mate with MS3116( )-24-61P

2.4.16 Port 1 SDLC - 15 pin metal shell D sub-miniature (gold plated female contacts)

2.4.17 Port 2 RS 232 - 25 pin metal shell D sub-miniature (gold plated female contacts)

2.4.18 Port 3 FSK - 9 pin metal shell D sub-miniature (gold plated male

contacts)

2.4.19 If input/output functions in addition to those covered in TS 2-1992 are supplied, an additional connector may be used. Such additional connector(s) must not be interchangeable with any other connectors on the front of the Control Unit. Multiple connectors for additional communication capabilities are acceptable.

2.5 The methods listed below must be available for Controller Unit programming:

2.5.1 Manual data entry via the front panel keyboard.

2.5.2 Data down-loading via telemetry from a system master that is connected to a Personal Computer in a closed loop system.

2.5.3 Data downloading from a Personal Computer via a Modem.

2.5.4 Data downloading from a Personal Computer via a Null-Modem cable.

2.5.5 Data downloading from one Controller Unit to another using the serial port of each Controller Unit.

2.5.6 Programming Security - It is desirable that the Controller Unit not have access code must have this function permanently disabled by the manufacturer.

2.5.7 This must be accomplished by software or firmware modifications, but not by keyboard entry.

2.6 Programming Displays - Controller Unit programming and status display must be menu driven. English Language and Traffic Engineering terminology must be used to facilitate programming. Programming must not require the use of reference cards or manuals. A content sensitive Help feature is desirable.

2.7 A copy function must permit copying all timing from one phase to another. It must also allow copying all coordination pattern data from one pattern to another.

2.8 The Controller Unit must have a back-up database stored in nonvolatile memory. The operator must be able to download these backup timings to the active database from the keyboard.

2.9 Means must be provided, for user definition, for the display of the software version in use.

2.10 display must be provided to assist the user in programming the Malfunction Management unit Programming Card, based on the Controller Unit ring structure and overlap programming.

2.11 The Controller Unit must provide all the control functions required by NEMA TS2 Standard. In addition, it must provide the features described in this section.

2.12 The Controller Unit must be programmable in any combination of two to sixteen phases and four ring configurations.

2.13 Phasing information must be programmable and must be stored

in removable EEPROM data memory modules. These modules must be interchangeable from controller to controller of the same manufacturer.

2.14 The Controller Unit must provide a Protected/Permissive sequence capability.

2.15 The Controller Unit must provide control of five section, Protected/Permissive left turn heads. When selected, this feature must cause the through (even) phase yellow to inhibit the left turn (odd) phase yellow.

2.16 The standard phase sequence of the Controller Unit must also be capable of being altered by coordination, time-of-day or external alternate sequence command. Each of the fifteen alternate sequence commands must allow reversing the normal phase sequence of eight phase pairs. The sixteen total sequences must offer every combination of lead-lag on an eight phase quad-left application.

2.17 It is desirable that a red output and don't walk output be generated for all non-used phases.

2.18 It is desirable that a red output be generated for all non-used overlaps.

2.19 Pedestrian operation must be provided for each phase.

2.20 The Controller Unit must provide sixteen internally generated overlaps. These must be individually programmable as standard, protected/permissive or negative.

2.21 The green, yellow and red intervals must be individually programmable following termination of the parent phase. Programming flexibility must permit assigning the overlap to lead, lag, or provide an advanced green time for a parent phase(s).

2.22 Overlap clearance -- An overlap that times an additional green, yellow and red interval upon termination of the true phase. This overlap clearance must be programmable to terminate or be allowed to time its clearance during the start of a pre-preemption call. Times for these additional green, yellow and red intervals must have a minimum range of 0 - 9.99 seconds in 0.1-second intervals. Timed overlap clearance must be enabled per phase, separate from standard overlaps.

2.23 The Controller Unit must provide a programmable conditional service feature. When selected, the Control Unit must service an odd-numbered phase once normal service to that phase has been completed and enough time for additional service exists on the concurrent even phase.

2.24 A conditional service minimum green time must be programmable for each phase. This interval must ensure a minimum green if the phase is conditionally served.

2.25 It must be possible to program the Controller Unit to re-service the even phase after conditionally serving an odd phase. Once an even phase has been conditionally re-serviced, the odd phase must not be conditionally served again until returning to the concurrent group that is timing.

2.26 The following features must be programmable for each phase:

2.26.1 Phase in use.

2.26.2 Locking/non-locking detector memory.

2.26.3 Vehicle recall.
2.26.4 Pedestrian recall.
2.26.5 Maximum recall.
2.26.6 Soft recall.

2.27 Soft recall must return the controller to the programmed phase in the absence of other calls.

2.28 If a phase is designated as a no-rest phase, the controller must not rest in the phase.

2.29 The Controller Unit must permit start and external start to be individually programmed by phase and interval. Start intervals must be green, yellow, red, or yellow with overlaps forced yellow.

2.30 During a power start condition, the Controller Unit must be capable of timing an all-red or flash interval before the power start phase(s) and interval is displayed.

2.31 The Controller Unit must provide guaranteed passage operation on a per phase basis. When selected, this feature must provide a full passage (vehicle extension) interval when a phase gaps out with a gap in effect less than the vehicle extension interval (preset gap).

2.32 The Controller unit must provide both single and dual entry operation. When selected, dual entry must cause the Control Unit to ensure that one phase is timing in each ring.

2.33 The Controller Unit must provide the following additional pedestrian functions:

2.33.1 Actuated phase rest in Walk.
2.33.2 Flashing Walk output.
2.33.3 Pedestrian clearance protection during manual control.
2.33.4 Pedestrian clearance through yellow.

2.34 The Controller Unit must provide automatic flash selection per the requirements of MUTCD. Both the flash entrance and exit phases must be programmable. Flashing must be controlled by either setting the voltage monitor output to be false or by flashing through the load switch driver outputs. External input, system command, or time of day must select automatic flash.

2.35 Coordination functions to control intersection cycle lengths, system offset relationships, and phase split percentages must be provided as a standard feature, with no need for additional modules or software.

2.36 A minimum of 40 coordination patterns must be provided. Each pattern must allow selection of an independent cycle length, offset and split. The coordination patterns must be selected using telemetry, or time base coordination commands.

2.37 The following functions must be programmable in each coordination pattern:

2.37.1 cycle length
2.37.2 offset
2.37.3 split for sixteen phases
2.37.4 permissive timing

2.37.5 coordinated phase split extension
2.37.6 alternate-phase sequence
2.37.7 phase re-service
2.37.8 split demand pattern
2.37.9 crossing artery pattern
2.37.10 coordinated phases
2.37.11phases to omit
2.37.12 phases to be placed on recall

2.38 It must be possible to omit selected phases during any coordination pattern. A phase must also be omitted if the phase split value is zero for the current coordination pattern.

2.39 The following recall modes must be programmable on a per phase basis for each coordination pattern:
2.39.1 Vehicle recall
2.39.2 Pedestrian recall
2.39.3 Maximum recall

2.40 One cycle length must be provided for each coordination pattern. The cycle must be adjustable over a minimum range of 30 - 255 seconds in 1-second increments.

2.41 The cycle length must serve as the reference time for all coordination timing.

2.42 For systems with a single system sync pulse, coordination timing must be synchronized to the leading edge of that pulse, which must serve as the master zero reference for all offset timing.

2.43 For hardwired systems with multiple sync pulses, the coordinator must lock onto the correct sync pulse. This is accomplished by trying different sync pulses and checking for reoccurrence during successive cycles.

2.44 After a valid system sync pulse has been received, the coordinator must check for the proper occurrence of the system sync pulse during each subsequent cycle. If a sync pulse does not occur, the coordinator must self-sync and continue to operate with the last set of coordination commands for a programmable period of time or number cycles. If a sync pulse does not occur within the programmed period (or until the first sync pulse is received), the coordinator must revert to the non-interconnected coordination mode.

2.45 Offset must normally be defined as the time period from the system sync pulse to the beginning of the leading coordinated phase green (local zero). The coordinator must also be capable of referencing the offset to the end of the coordinated phase green.

2.46 Offsets must be programmable using percentage or seconds. The range must be from 0 – 99% of the cycle length in 1% increments or 0 - 255 seconds in 1 second increments.

2.47 Offset changes must be achieved by adding or subtracting cycle time over multiple cycles to allow a smooth transition to the new offset. Offset correction using dwell must also be selectable.

2.48 Each split must provide a split interval for each of sixteen phases. The split interval must be programmable using percentage or seconds. The range must be from 0 – 99% of the cycle length in 1% increments or 0 - 255 seconds in 1 second increments. Split interval settings must determine the maximum time, including vehicle clearance (yellow and red), for non-coordinated phase, or the minimum time for a coordinated phase.

2.49 Permissive periods must be provided to control the time period during which coordinated phases are released to service calls on non-coordinated phases.

2.50 If actuated coordinated phases are in use, it must be possible to re-serve non-coordinated phases within the same cycle. A phase must be re-served only if the permissive period for the phase indicates there is sufficient time remaining in the cycle to service the phase.

2.51 The coordinator must be capable of implementing dual coordination at an intersection where two arteries are under control of separate masters.

2.52 The coordinator must provide a minimum of two split demand detector inputs, which must allow the selection of a preferred split plan based on intersection demand.

2.53 The coordinator must provide a free mode of operation, where all coordination control is removed.

2.54 Free mode operation must be selectable by coordination commands, by external input or by keyboard entry. The coordinator must revert to the free mode when active controller inputs or functions would interfere with coordination. Such inputs or functions must include the following:

- 2.54.1 Manual control enable
- 2.54.2 Stop time
- 2.54.3 Automatic flash
- 2.54.4 Preemption

2.55 The controller must allow manual override of the current coordination command from the keyboard. The manual command must allow selection of any coordination pattern to be in effect.

2.56 The coordinator must be capable of operating with any of the following interconnect types:

- 2.56.1 Non-interconnected coordination (time-based)
- 2.56.2 Telemetry
- 2.56.3 Hardwired

2.57 The coordinator must be compatible with fixed-time interconnect, which provides the sync pulse superimposed of the offset

lines. It must also operate within an interconnected system using a separate sync line. The non-interconnected coordination mode must serve as a backup when using telemetry or hardwired interconnect.

2.58 The coordinator must output the coordination command, including sync pulse. This feature must permit the controller to be used as a time-of-day master in a hardwired interconnected system.

2.59 The Controller Unit must provide a minimum of six railroad-fire-emergency vehicle preemption sequences plus four bus preemption sequences. Preemption capability must be standard and must not require additional modules or software.

2.60 The six railroad-fire-emergency vehicle preemptors must be programmable as a priority or non priority type. Priority preemptor calls must override non-priority preemptor calls. Low-numbered priority preemptors must override higher-numbered priority preemptor calls. Non-priority preemptor calls must be serviced in the order received.

2.61 Each preemptor must provide a locking and non-locking memory feature for preemptor calls. If a preemptor is in the non-locking mode and a call is received and dropped during the delay time, the preemptor must not be serviced.

2.62 Preemptor timing intervals must be programmable from a minimum range of 0-255 in one second increments or a minimum range of 0-9.99 in one-tenth second increments, depending on function.

2.63 A programmable delay time interval must be provided to inhibit the start of the preemption sequence. This interval must begin timing upon receipt of a preemption call.

2.64 An inhibit time must be provided as the last portion of the delay time interval. During this time, phases that are not part of the preempt sequence must be inhibited from service.

2.65 Programmable duration time must be provided to control the minimum time that a preemptor remains active. This time must be programmable from a minimum range of 0-255 in one second increments.

2.66 Programmable maximum time must be provided to control the maximum time a preemptor remains in the hold interval. The preemptor maximum time interval must be inhibited if the preemptor is programmed as a priority preemptor.

2.67 Phases timing at the beginning of a preemption sequence must remain in effect for a minimum time before the controller advances to the next sequential interval. If the phase has been timing for longer that the programmed preemptor minimum time, the controller must immediately advance to the next sequential interval. Minimum times must be programmable for the following intervals:

- 2.67.1 Green
- 2.67.2 Yellow
- 2.67.3 Red
- 2.67.4 Pedestrian clearance
- 2.67.5 Overlap yellow

2.68 A phase must advance immediately to pedestrian clearance if it has been timing a WALK interval at the beginning of a preemption sequence. It must be possible to time the minimum pedestrian clearance through the yellow interval, or alternatively to advance immediately to yellow. During preemption, pedestrian indicators must be selectable as being a solid DON'T WALK, OFF (blank) or fully operational.

2.69 If an overlap is in effect when the preemption sequence begins, it must be possible to terminate the overlap so that it remains red for the remainder of the preemption sequence. Overlaps terminating or forced to terminate must time the preemptor minimum yellow and red clearance times.

2.70 Each preemptor must provide user-programmable green, yellow and red track clearance intervals. These must begin timing immediately after the preemptor minimum red interval.

2.71 Up to two permissive phases must be selectable as track clearance phases. During the track clearance period, the selected phases must time the track clearance green, yellow and red intervals once, and then advance to the hold interval. If track clearance phases are not selected the track clearance interval must be omitted from the preempt sequence. Controller interval timing must be used if track clearance interval times have been programmed as zero.

2.72 The preemption hold interval must begin immediately after track clearance. It must remain in effect until the preemptor duration time and minimum hold times have elapsed and the preemptor call has been removed or the preemptor maximum time has be exceeded. During the preemption hold interval, any one of the following conditions must be selectable:

- 2.72.1 Hold phase green
- 2.72.2 Limited phase service
- 2.72.3 All red
- 2.72.4 Flash

2.73 Any valid phase, except a track clearance phase, must be selectable as a hold phase. If hold phases are not selected, the controller must remain in all red during the hold interval. When flash is selected for the hold interval, up to two permissive phases must be selected to flash yellow, and the remaining phases must flash red. Overlaps associated with the phases flashing yellow must also flash yellow unless they have been forced to terminate, in which case they must remain red.

2.74 Each preemptor must provide a user-programmable green, yellow and red hold interval, during which the hold phase(s) must operate normally, except that the minimum green interval time must equal the hold green time. At the completion of the hold green interval, the Controller Unit must time the hold yellow and red clearance intervals prior to transfer to the exit phases.

2.75 Up to two permissive exit phases must be selectable to time after the preemption sequence has been completed. These must serve as

transition phases to return the Controller Unit to normal operation. It must also be possible to place calls on selected phases upon exiting preemption.

2.76 Preemptor linking must permit preemption sequences, where lower-priority preemptors may call the higher-priority preemptors upon termination of their preemption sequence.

2.77 Preemptor active outputs must be provided for each of the preemptors. The output must be set to ON when the preemption sequence begins and must remain ON for the duration of the sequence.

It must also be possible to program preempt active outputs to be ON only during preempt hold intervals. Additionally, it must be possible to program the non-active, non-priority preemptor outputs to false while another preemptor is active.

2.78 Preemptors must normally override automatic flash. It must be possible to inhibit this feature for each preemptor.

2.79 It must be possible to program a solid yellow and red clearance time when a preemption call is received and the controller is in MUTCD FLASH or LOCAL controller flash. These timings must be possible for each phase and overlap. Examples of which, intersection is in MUTCD FLASH, phases 2 & 6 are flashing yellow and phases 4 & 8 are flashing red. A preemption call is received, phases 2 & 6 go from flash to a timed solid yellow and phases 4 & 8 go to a solid red. When phases 2 & 6 time out they go to red and the beginning of preemption begins. At the end of preemption the intersection goes through a complete color cycle and then to whichever flash is requested. The timing range must be from 3.0 seconds for yellow clearance to a minimum of 25 seconds in 1-second intervals. The all red interval must be from 1.0 seconds to a minimum of 9.9 seconds in 0.1-second intervals.

2.80 Four bus preemptors must provide control for bus or other low-priority vehicles. Bus preemptors must have low priority and must be overridden by railroad-fire-emergency vehicle preemptor calls.

2.81 A 6.25 pulse-per-second signal with a 50% duty cycle must identify a bus preemptor call. Bus preemptor calls must be capable of preemptor call memory and must be served in the order received.

2.82 As a minimum, bus preemptor timing intervals must be programmable from a minimum range of 0-255 in one second increments or a minimum of 0-9.99 in one tenth second increments depending on the function.

2.83 A re-serve time must be provided to avoid excessive utilization of the same bus preemptor. If a call is received before the re-serve time has elapsed, the bus preemptor must not be re-serviced. If re-service time has not been entered then all phases with a call when leaving the bus preemption sequence must be serviced before the bus preemptor may be served again.

2.84 Bus preemptors must provide delay, inhibit, and maximum time functions similar to those for railroad-fire-emergency vehicle preemptors described above.

2.85 Bus preemptors must provide the following entrance intervals:

2.85.1 Green
2.85.2 Yellow
2.85.3 Red
2.85.4 Pedestrian clearance
2.85.5 Overlap yellow

2.86 At the completion of the entrance red clearance, the bus preemptor must advance to the hold green interval. During this interval, up to two permissive phases must be programmable to remain green until:

2.87 The minimum hold time has elapsed and the bus preemptor call has been removed.

2.88 The preemptor maximum time has be exceeded.

2.89 It must be possible to program the controller to allow concurrent phases to be serviced for a bus preemptor with only one phase selected as the hold interval phase.

2.90 If a preemptor call is active when power is restored to a Controller Unit, the fault/voltage monitor output must be set to FALSE, placing the intersection in flash. Similarly, if external start is applied during a preemption sequence, the intersection must be set to flash. Intersection flash must remain in effect until the preemptor call has been removed and the preemptor duration time has elapsed.

2.91 Input must be provided to stop timing of the current active preemptor under control of the MMU/CMU.

2.92 Preemptor safety interlock must be provided to cause the intersection to go into flash whenever the Controller Unit has been removed or has not been programmed for preemption. This must be achieved with an appropriate signal to the MMU/CMU.

2.93 The Controller Unit must include time-based control. This capability must be a standard feature and must not require additional modules or software.

2.94 The controller must provide a time-of-day (TOD) clock, which must be used, for all time- based control functions. The only required clock settings must be the current time (hour, minute and second) and date (month, day and year). Day of week and week of year must be automatically computed from the date setting.

2.95 During normal operation, the TOD clock must use the power line frequency as its time base. When power is removed, a crystal oscillator for up to 30 days must maintain the time. The oscillator must have a timing

accuracy of +/- 0.005% over the entire NEMA temperature range as compared to the Universal Coordinated Time Standard.

2.96 In addition to entering time and date via the keyboard, it must be possible to download the information from another controller, a computer or a system master.

2.97 The Controller Unit must include a time reset input. This feature must reset the TOD clock whenever the time reset input is TRUE.

2.98 The TOD clock must automatically compensate for leap year and must be programmable to automatically switch to daylight savings time.

2.99 Time-based control must utilize a yearly program format. The year program must consist of a minimum of 53 programmable weeks. Each week designated to one of ten-week programs. For each week-program, one of sixteen day-programs must be capable of being assigned for each day of the week. Each day program must consist of a variable number of program steps that define a program for the entire day.

3.0 There must be a minimum of 36 holiday or exception day programs, which override the normal day program. Holiday programs must be capable of being set as floating (occur on a specific day of the year). It must be possible to program a fixed holiday so that it automatically repeats in the following year.

3.1 Separate program step control must be provided for non-interconnected coordination (NIC) and TOD functions.

3.2 It must be possible to manually force any of the non-interconnected or TOD program steps to override the current program step. The forced step must be entered from the keyboard and must remain in effect until removed.

3.3 A minimum of 100 non-interconnected coordination program steps must be available for the day-programs. These must not have to be entered in any special sequence. It must be possible to add and delete steps from a day-program without affecting any other day-program. As a minimum, each of the program steps must permit selection of the following functions:

3.3.1 Day program assignment
3.3.2 Start time
3.3.3 Coordination pattern
3.3.4 System override

3.4 Selection of system override must allow the coordination pattern selected by the program to override the current telemetry or hardwired system commanded.

3.5 When operating in the non-interconnected coordination mode the synchronization point for all cycles must be referenced to a user selected reference time (sync reference), last event of last sync as selected from the keyboard. The reference time is that time at which all cycles must be reset to zero.

3.6 If the sync reference time is selected, the synchronization point for the cycle selected by the current program step, must be computed using the present time, sync reference time, and cycle length periods having occurred since the sync reference time.

3.7 A minimum of 50 TOD program steps must be available for the day programs. These program steps must be separate from the non-interconnected coordination program steps described above. TOD program steps must not have to be entered in any special sequence. It must be possible to add and delete steps from a day-program without affecting any other day-program.

3.8 Each of the TOD program steps must permit selection of the following functions:

- 3.8.1 Day program assignment
- 3.8.2 Start time
- 3.8.3 Automatic flash
- 3.8.4 Red rest
- 3.8.5 Dimming
- 3.8.6 Alternate vehicle extension interval
- 3.8.7 Detector logging
- 3.8.8 Detector diagnostic plan
- 3.8.9 Alternate phase sequence
- 3.8.10 Control of eight special functions
- 3.8.11 Control of the following by phase functions: Max. 2, Max. 3,Vehicle Recall, Max.Recall, Pedestrian Recall, Condition Service and Phase Omit

3.9 Controller Unit must provide a minimum of 64 vehicle detector inputs. Each input must be designated to any phase and be programmable as to detector function. Extend and delay timing must be provided for each detector. Each detector must be capable of operating in a lock or non-lock mode.

3.10 The Controller Unit must provide detector cross switching, which permits all vehicle detectors to alternately place calls on their assigned phases and their assigned cross-switch phases. If the assigned phase is not green and the cross-switch phase is green, the detector must place calls on the cross

switch phase. If the coordinator omits the assigned phase, the detector must place calls on the cross switch phase.

3.11 Each vehicle detector must be user-programmable to operate as one of the following 7 detector types:

3.11.1 **Type 0**- Detector must operate as a standard detector providing one call per actuation.

3.11.2 **Type 1 Extend/Delay**- Detector must operate as follows: When the phase green and a call is detected then dropped (indicating passage of a vehicle), the extend timer must begin timing and the call must be held for the length of the extend time. When the phase is not green and a call is detected, the call must not be acknowledged by the Controller Unit until the delay time has elapsed.

3.11.3 **Type 2 Extend/Delay Call -** Detector must operate as follows: When the phase is green and a call is detected then dropped (indicating passage of a vehicle), the extend timer must begin timing and the call must be held for the length of the extend time. If a gap out occurs further calls must not be placed on the Controller Unit until the delay time has elapsed. When the phase is not green the detector must operate as a Type 0 detector.

3.11.4 **Type 3 Stop Bar -** Detector must operate as follows: Vehicle calls must be accepted only when the phase is not green. When a call is detected, it must be held until the detection area is empty. Once the detection area is empty no further calls must be accepted until the phase is again not green.

3.11.5 **Type 4** Stop Bar - Detector must operate as follows: Vehicle calls must be accepted only when the phase is not green. When a call is detected, it must be held until the detection area is empty. The extend timer must begin timing with the phase green. Once the extend timer times-out or the detection area is empty, no further calls must be accepted until the phase is again not green.

3.11.6 **Type 5** Stop Bar - Detector must operate as follows: Vehicle calls must be accepted only when the phase is not green. When a call is detected, it must be held until the detection area is empty. The extend timer must begin timing with the phase green. If a call is received before the extend timer has timed-out, the timer must be reset. Timer reset must occur until a gap between the calls is large enough to allow the extend timer to time-out. Once time-out has occurred

3.11.7 **Type 4 Calling -** Detector must accept one call while the phase is red.

3.12 Each detector input must be capable of functioning as one of 8 system detectors.

3.13 Vehicle detectors must be capable of being assigned to a minimum of 2 speed detector sets. Speed must be detected using one or two detector configurations. When using two detectors, speed must be calculated using a programmable distance between detectors and travel time between detectors.

3.14 The Controller Unit must provide a minimum of 8 pedestrian detector inputs. Each Pedestrian detector must be capable of being assigned to any phase.

3.15 The Controller Unit must be capable of communicating with an on-street system master. A separate telemetry module must provide this capability, which must be included in the Controller Unit when required by the plans and specifications. The telemetry module must receive system master commands and data transmissions. In addition, it must transmit the Controller Unit status, data base and system detector information to the system master.

3.16 The telemetry module must allow the Controller Unit to receive, as a minimum, the following commands:

- 3.16.1 Cycle, offset, and split (coordination pattern)
- 3.16.2 System sync
- 3.16.3 Special function commands (minimum of four) Free and flash mode commands
- 3.16.4 Time and date
- 3.16.5 Request for local status
- 3.16.6 Recall to Max.

3.17 All commands must occur more than once in any three-second period to be recognized.

3.18 All mode and special function commands must be cleared after 20 minutes of loss of communication between Controller Unit and system master.

3.19 The status of each of the following functions must be transmitted to the system master in response to a local status request:

- 3.19.1 Green and yellow status for all phases and overlaps
- 3.19.2 Walk and pedestrian clearance status for all phases
- 3.19.3 Vehicle and pedestrian detector status
- 3.19.4 Phase termination status
- 3.19.5 Local time
- 3.19.6 Coordination status
  - (1)Commandsource
  - (2) Sync or transition status of coordinator
- 3.19.7 Conflict flash status
- 3.19.8 Local flash status
- 3.19.9 Preempt activity and calls

3.20 Volume and occupancy data from a minimum of 8 system detectors

3.21 Speed data from a minimum of two speed detector sets

3.22 Maintenance required (cabinet door open) status

3.23 Status of two user-defined alarms

3.24 The status of each of the following parameters must be calculated on a per-cycle basis and transmitted to the system master:

3.24.1 Actual time spent in each phase
3.24.2 Time of day at end of cycle
3.24.3 Phases forced off during cycle
3.24.4 Type of coordination operation
3.24.5 Whether transitioning to new offset
3.24.6 Cycle, offset, and split in effect during last cycle
3.24.7 Flash status if operation is Free

3.25 The telemetry module must provide the capability to upload/download the entire intersection database. Phase assignments for overlaps and preemptors must not be downloaded to preclude unsafe Controller Unit operation. It must be possible to inhibit downloading of phases in use and left-turn head control

3.26 Telemetry must utilize TDM/FSK data transmission at 1200 baud over four-wire communication lines. These may be leased lines (Type 3002, voice grade, unconditioned) or dedicated cable. Optional fiber optic communications capability must also be available. The nominal transmitter output level must be 0 DBM into a 600-ohm load. receiver sensitivity must be -34 DBM and must be adjustable from -40 to +6 DBM.

3.27 The Parity and error checking must be employed to assure transmission and reception of valid data. Indicators must be provided on the telemetry module to show telemetry activity as follows: transmit, receive carrier, and valid data.

3.28 In the event of a telemetry failure, the Controller Unit must revert to the non-interconnected coordination mode of operation after it has self-synchronized for a number of cycles, which must be selectable for 0-255 or has timed out per selectable time interval.

3.29 The Controller Unit must include both automatic and operator-initiated diagnostics. This capability must be a standard feature and must not require additional modules or software.

3.30 Automatic diagnostics must verify memory, MMU compatibility programming, and microprocessor operation each time power is reapplied to the Controller Unit. After power has been applied, diagnostics must continually verify the operation of essential elements of the Controller Unit including at a minimum: PROM, EEPROM, communications, and the microprocessor.

3.31 Operator initiated diagnostics must allow the operator to verify proper operation of all Controller Unit input, output, communications, keyboard, and display functions. Both manual and automatic test modes must be provided.

3.32 Time-of-day controlled detector diagnostics must be provided that allows testing vehicle and pedestrian detectors for no activity, maximum presence, and erratic output.

3.33 Minimum of two detector diagnostic plans must be provided. These plans must be selectable on a time-of-day basis. This must allow varying the detector diagnostic intervals to correspond with changes in detector activity.

3.34 Diagnostics for NEMA TS 2 detectors connected to the Controller Unit using a BUS Interface Unit (BIU) must also include detection of watchdog, open and shorted loop, and Excessive inductance change failures.

3.35 The Controller Unit must be capable of logging and reporting detector activity, detector failures, and the occurrence of selected events or alarms. Logs must be capable of being printed or displayed on the front of the Controller Unit.

3.36 The Controller Unit must include a detector log buffer capable of logging volume, occupancy and average speed for selected vehicle and speed detectors.

3.37 The detector-logging interval must be keyboard selectable as 5, 15, 30, or 60 minutes.

3.38 The Controller Unit must include a detector failure log buffer capable of storing a minimum of 90 time and date-stamped detector failure events. Once logged, detector failure events must remain in the log until cleared or the log buffer capacity is exceeded at which time the oldest detector failure events must be overwritten.

3.39 All detector diagnostic failures must be recorded in the detector failure log including: no activity, maximum presence, erratic output, watchdog failure, open loop, shorted loop, and excessive inductance change. If a detector recovers after a diagnostic failure, a detector on-line event must be stored in the detector failure log.

3.40 The Controller Unit must include an event log buffer capable of storing a minimum of 200 time and date-stamped events or alarms. Once logged, events must remain in the buffer until cleared or the log buffer capacity is exceeded at which time the oldest events must be overwritten.

3.41 At a minimum the following events must be logged:

- 3.41.1 Communication failures
- 3.41.2 Coordination faults
- 3.41.3 MMU and local flash status
- 3.41.4 Preempt
- 3.41.5 Power ON/OFF
- 3.41.6 Low battery
- 3.41.7 Status of a minimum of two alarm inputs
- 3.41.8 An on-line event must be logged when an event or alarm returns to normal status

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

3.43 These standards define the minimum requirements for a TS2 Type A1 cabinet, both inside and out.

3.44 The performance and construction of the cabinet must 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 must be permanently applied externally on or near the front of the product. Programming and maintenance manuals for approved products must be identical in nature to that approved for use during the evaluation period of

the product. The Department must be notified of all changes to the documentation. Manufacturer specific enhancements are acceptable; however no function or device must preclude the interchangeability of an auxiliary product with another product of like NEMA specification within a controller assembly. product of like NEMA specification within a controller assembly.

3.45 The cabinet and door(s) must be constructed from type 5052-H32 aluminum with a minimum thickness of 0.65 inches. The top, door, and each side of the cabinet must each be a single sheet of aluminum. Welding pieces together to form any of these surfaces must not be permitted. External welds must be made by using the Heliarc welding method, whereas internal welds will be made by the wire welding method. All welds must be neatly formed and free of cracks, blowholes and other irregularities.

3.46 All inside and outside edges of the cabinet must be free of burrs. All sharp edges must be made smooth.

3.47 The cabinet must be designed and manufactured with materials that will allow ridged mounting, whether intended for pole, base or pedestal mounting. The cabinet must not flex on its mounting.

3.48 A rain channel must be incorporated on all four (4) sides of the main door opening to prevent liquids from entering the enclosure. Cabinet door openings must be double-flanged outward on all four (4) sides to produce the rain channel.

3.49 The top of the cabinet must incorporate a 1 (inch) slope toward the rear to prevent rain accumulation.

3.50 The cabinet must be supplied with a natural aluminum finish. Sufficient care must be taken in handling to ensure that scratches are minimized. All surfaces must be cleaned of all oil residue and must be free from weld flash.

3.51 All interior seams must be sealed with RTV sealant or equivalent material.

3.52 All cabinets must be supplied with two removable shelves manufactured from 5052-H32 aluminum having a minimum thickness of 0.65 inches. Shelves must have a minimum depth of 10.5 inches.

3.53 One set of vertical "C" channels must be mounted on each interior wall of the cabinet for the purpose of mounting the cabinet components. The size six-(6) cabinets must have an additional set of channels mounted on the left and right-side walls. The mounting channels must provide infinite horizontal and vertical adjustments of mounted equipment and shelves. The channels must accommodate spring-mounted nuts or studs. All mounting rails must extend to within four (4) inches of the top and bottom of the cabinets. Rivets or pop-rivets of any kind must not be used in the cabinet or on the main panel. No bolts or screws must protrude through the outside walls, top, bottom, or sides of the cabinet.

3.54 All cabinets must be supplied with four (4) anchor bolts to properly secure the cabinet to its base.

3.55 The cabinet must have an open bottom that is surrounded by a heavy-duty attachment flange (lip) made of double thickness material having a minimum thickness or 0.25 inches. Around the opening, the flange must be

three (3) inches wide, plus or minus one-half (1/2) inch. One-inch slots must be provided in all four corners for the anchor bolts or for securing the removable bottom panel of pole mounted cabinets.

3.56 All size 5 cabinets must be provided with stiffener plates Made from 0.250-inch aluminum and tack welded to the top and bottom of the rear wall to allow pole mounting.

3.57 All size 5 cabinets must be fitted with a removable 0.250-inch-thick bottom panel. The bottom panel of the cabinet must be removable to allow the cabinet to be used as a base mount type if desired. A closed cell neoprene pad having a minimum thickness or 0.5 inches must be installed between the cabinet and the bottom panel to prevent dust and moisture from entering the cabinet.

3.58 Each cabinet must be of sufficient size to accommodate all equipment without crowding. Each piece of equipment must have its own space on a shelf. It must not be necessary to move any other piece of equipment in order to service any component or unit. All auxiliary equipment must be accessible for removal or installation without moving any other component in the cabinet. The minimum cabinet sizes are as follows:

3.59 Size 5 cabinets -- 50" H x 36" W x 17" D

3.60 Size 6 cabinets -- 55" H x 44" W x 26" D

3.61 Size 5 cabinets must be pole-mounted cabinets. All pole-mounting hardware must be supplied and must be made of rustproof material. Top and bottom mounting brackets must be supplied and must permit the use of two (2) bands on each bracket (for secure mounting). Mounting brackets must allow the use of a minimum of 3/4-inch wide bands.

3.62 Size 5 cabinets must be supplied with an Extender Base that is at least 15 Inches in height. The extender base must be made of 5052-H32 aluminum having a minimum thickness of 0.65 inch. The top and bottom opening must match the bottom of the cabinet and must have the same mounting bolt pattern as the cabinet. Extender base, mounting bolts and gasket must be supplied as one unit and separate from the size 5 cabinets.

3.63 All cabinets must be equipped with a three- (3) position alarm and light switch bracket. This bracket Must be attached to the top right corner of the door opening.

3.64 A stiffener plate must be welded across the inside of the main door to prevent flexing. The stiffener plate must not cover or prevent access to any door component(s).

3.65 The lower section of the cabinet door must be equipped with a louvered air entrance. The air inlet must be large enough to allow sufficient airflow per the rated fan capacity. Louvers must satisfy the NEMA rod entry test for 3R ventilated enclosures. A removable fiberglass, air filter must be supplied with each cabinet. The filter must be secured to the air entrance in such fashion as to maintain close contact, at all times, to the louvered air entrance. The filter retainer must be a slide fit design with no bolts or springs utilized to secure the filter to the door opening.

3.66 The roof of the cabinet must incorporate an exhaust plenum with a vent screen. Perforations in the vent screen must not exceed 0.65 inches in diameter.

3.67 The main door must be equipped with a three-point draw roller type latching mechanism. The push rods must be turned edgewise at the outward supports and must be 0.250 inch by 0.750-inch aluminum, minimum. The push rods must maintain a uniform thickness along their entire length. A reduction in thickness at the center latch point must not be accepted.

3.68 Rollers must have a minimum diameter of 0.875 inch and will be made of nylon. The center catch must be fabricated from 0.187 aluminum.

3.69 The handle on the main door must utilize a stainless-steel shank of 5/8 inches minimum diameter. The handle must include a hasp for the attachment of an optional padlock. The cabinet door handle must rotate counterclockwise to open. The handle must not extend beyond the perimeter of the main door at any time. The lock assembly must be positioned so that the handle must not cause any interference with the key when opening the cabinet door. When the door is closed and latched, the door must automatically lock. It must not be necessary to use a key in order to lock the door.

3.70 The main cabinet and police panel door hinges must be a one-piece, continuous piano hinge. The hinge must be located on the right side of the door when viewed from the front. The hinge and pin must run the entire length of the door. All cabinet and police panel door hinge pins must be capped at the top and bottom by weld to render the pin tamper proof.

3.71 The hinges must be made of 0.093 thick aluminum and must have a 3-inch open width with a 0.250-inch diameter stainless steel hinge pin. Door hinge must be bolted to the cabinet and door with ¼-20 stainless steel carriage bolts and ny-lock nuts.

3.72 The main door must be equipped with a mechanism to automatically hold the door open at approximately 90, 125, and 150 degrees, in windy conditions. The mechanism must be pinned to prevent separation from the track. The door holding track must be reinforced and tack welded along its top and bottom. Manual placement of the mechanism must not be required by the field technician.

3.73 The main door must be equipped with a Corbin tumbler lock number 15481RS or approved equivalent. The lock must be of brass construction and must have a swing-away cover. Two Maryland No. 2 keys must be supplied and attached to each cabinet door upon shipment.

3.74 A switch compartment must be provided on the main door.

3.75 The opening for the switch compartment door must be double flanged on all four sides and must incorporate a rain channel on all four sides.

3.76 The police door-in-door must be provided with a treasury type lock Corbin No. R357SGS series, or approved equivalent. The lock must be of brass construction and must have a swing-away cover. All cabinets must have a police panel door that utilizes a slam shut type latching mechanism. Two police keys must be supplied and attached to each cabinet door upon shipment.

3.77 The door hinge for the switch compartment must be 0.063-inch stainless steel with a 0.60-inch diameter stainless steel hinge pin.

3.78 Type 1 And Type 2 Terminals and Facilities Main Panel Design

3.79 The main panel must be constructed from 5052-H32 brushed aluminum of 0.090 inches minimum thickness and formed so as to minimize any flexing when plug-in components are installed.

3.80 All main panels must be hinged at the bottom to allow easy access to all wiring on the rear of the panel. The cabinet back panel conductors must be arranged to allow the top of the panel to be tilted out through the main cabinet door. Removal or disconnecting of any conductors or equipment mounted on the side walls of the cabinet must not be necessary.

3.81 The main panels must be fully wired in the following configurations:

3.81.1 Type 1 Configuration 3 -- Twelve load switch sockets, (eight vehicle sockets and four pedestrian sockets) six flash transfer relay sockets, one flasher socket, and two main panel BIU rack positions. This configuration must be installed into all size five (5) cabinets.

3.81.2 Type 1 Configuration 4-- Sixteen load switch sockets, (eight vehicle sockets, four pedestrian sockets and four overlap sockets) eight flash transfer relay sockets, one flasher socket and two main panel BIU rack positions. This configuration must be installed into all size six (6) cabinets.

3.81.3 Type 2 Configuration 3 -- Twelve load switch sockets, (eight vehicle sockets and four pedestrian sockets) six flash transfer relay sockets, one flasher socket. This configuration must be installed into all size five (5) cabinets.

3.81.4 Type 2 Configuration 4 - Sixteen load switch sockets, eight vehicle sockets, four pedestrian sockets and four overlap sockets) eight flash transfer relay sockets. This configuration must be installed into all size six (6) cabinets.

3.82 Reference designators for all load switch and flash transfer relay sockets must be silk-screen labeled on the front and rear of the main panel.

3.83 Up to eight load switch sockets may be positioned horizontally or stacked in two rows on the main panel. If more than eight load switch sockets are required, they must be mounted in two horizontal rows. All load switch sockets, flasher sockets, and flash transfer sockets must be mounted on the main panel only.

3.84 A bracket extending at least half the length of the load switch must support all load switches. This support must be rigidly mounted to the main panel and be removable for maintenance by using hand tools only.

3.85 In Type 1 Main Panels rack style mounting must be provided to accommodate the required BIU's per the configuration listed in section 3.3 above. A duel -- row, 64 -- pin female din 41612 Type B connector must be provided for each BIU rack position. Card guides must be provided for both edges of the BIU. Terminal and facilities BIU mounting must be an

integral part of the main panel. Detector rack BIU mounting must be an integral part of the detector rack.

3.86 In Type 1 Main Panels all BIU rack connectors must have pre-wired address pins corresponding to the requirements of the TS 2 Specification. The address pins must control the BIU mode of operation. BIU's must be capable of being interchanged with no additional programming.

3.87 All twelve position main panels must have all field wires terminated on one row of horizontally mounted terminal blocks. All sixteen position main panels must have all field wires terminated within one or two rows of horizontally mounted terminal blocks. If two rows are used, the upper row must be wired for the pedestrian and overlap field terminations. The lower row must be reserved for phase one through eight vehicle field terminations.

3.88 All field output circuits must be terminated on a non-fused terminal block with a minimum rating of 20 amps.

3.89 All Type 2 Main panels must provide means of programming the controller phase outputs to load switch inputs with only the use of a screwdriver.

3.90 Permanent alphanumerical labels must identify all field input/output (I/O) terminals. All labels must use standard nomenclature per the NEMA TS 2 Specification.

3.91 Type 1 Main Panels must have as a minimum; terminals provided for the input/output signals listed in table 5.3.1—2 for terminal facilities configurations 3 and 4 of NEMA TS2—1992.

3.92 Type 2 Main Panels must have as a minimum; sufficient screw terminals must be provided for the termination of the input/output functions described in section 5.3.2 of the TS2—1992 standard.

3.93 All flash color selection must be accomplished at the field terminals with the use of a screwdriver only. It must also be possible to select, through terminal connections, which of the two flasher circuits is connected to each phase. All cabinets must be wired so that flasher circuit output #1 must be wired for phases 2, 3, 6, and 7, overlap B and overlap D. Flasher output circuit #2 must be wired for phases 1, 4, 5, and 8, overlap A and overlap C. All cabinets must be pre-wired to flash phases 2 and 6 yellow and all other phases and overlaps red.

3.94 Field terminal blocks must be wired to use a minimum of three positions per vehicle, pedestrian and overlap phase. All bolts and screws used for electrical connections must be stainless steel. All equipment grounds must run directly and independently to the Earth ground bus bar. All neutral conductors must be carried throughout the cabinet without a break, splice, or fuse unless otherwise noted. A separate insulated Neutral Bus Bar with a minimum of twenty positions or terminals sized to allow three #12 wires per terminal must be mounted to the main panel. A separate insulated Earth Ground Bus Bar with a minimum of ten positions or terminals sized to allow three #12 wires per terminal must be mounted to the main panel. The mounting of each bus bar must be ridged with minimal flexing at all points on the bar.

3.95 Signal output terminals must be screw type, Compression type termination must not be acceptable.

3.96 The main panel must contain a flasher capable of operating a 15-amp, 2-pole, NEMA solid state flasher. A bracket that extends at least half its length must support the flasher.

3.97 As a minimum, a RC network must be wired in parallel with each group of three flash-transfer relay coils. A RC network must be installed on all other relay coils.

3.98 All logic-level, NEMA Controller Unit and Malfunction Management Unit input and output terminations on the main panel must be permanently labeled. Cabinet prints must identify the function of each terminal position. All screws and terminals must be made of stainless steel.

3.99 Type 1 Main Panel terminal blocks for DC signal interfacing must have a number 6-32 x 7/32-inch screw as a minimum. All screws and terminals must be made of stainless steel. Functions to be terminated must be as specified in the listing of input/output Terminals in the NEMA TS2--1992 Standard document (Section 5).

3.100 Type 2 Main Panels must have as a minimum; terminal blocks must be provided at the top of the main panel to provide access to the Controller Unit's programmable and non-programmable inputs and outputs. Terminal blocks for DC signal interfacing must have a # 6-32 x 7/32-inch screw minimum. All screws and terminals must be made of stainless steel.

3.101 All main panel wiring must conform to the following wire size and color:

Green or Walk load switch output	brown wire	16 AWG
Yellow load switch output	yellow wire	16 AWG
Red / Don't Walk load switch output	red wire	16 AWG
MMU (other than AC power)	optional color	22 AWG
Controller Unit Input / Output	blue wire	22 AWG
AC Line (power panel to main panel)	black wire	***
AC Line (main panel)	black wire	***
AC Neutral (power panel to main panel)	white wire	***
AC Neutral (main panel)	white wire	***
Earth ground (power panel)	green wire	***
Logic ground	gray wire	22 AWG
*** Gauge varies with power panel / main panel set. Unless otherwise noted, wire size must comply with NEMA Standard TS 2 - 1992 Table 5.2.5-1.		

3.102 All wiring, 14 AWG and smaller, must conform to MIL-W-16878/1, type B/N, 600V, 19-strand tinned copper. The wire must have a minimum of 0.010 inches thick PVC insulation with clear nylon jacket and rated to 105 degrees Celsius. All 12 AWG and larger wire must have UL listed THHN / THWN 90 degrees Celsius, 600 V, 0.020 inches thick PVC insulation and clear nylon jacketed

3.103 All wiring, 14 AWG and smaller, must conform to MIL-W-16878/1, type B/N, 600V, 19-strand tinned copper. The wire must have a minimum of 0.010 inches thick PVC insulation with clear nylon jacket and rated to 105 degrees Celsius. All 12 AWG and larger wire must have UL listed THHN / THWN 90 degrees Celsius, 600 V, 0.020 inches thick PVC insulation and clear nylon jacketed.

3.104 All Controller Unit and Malfunction Management Unit cables must be of sufficient length to allow the units to be placed on either shelf or the outside top of the cabinet in the operating mode. Connecting cables must be sleeved in a braided nylon mesh. The use of exposed tie-wraps or interwoven cables are unacceptable.

3.105 All cabinet configurations must be provided with enough RS-485 Port 1 communication cables to allow full capabilities of that cabinet. Each communication cable connector must be a 15-pin metal shell D sub-miniature type. The cable must be a shielded cable suitable for RS-485 communications.

3.106 All main panels must be pre-wired for a Type-16 Malfunction Management Unit.

3.107 All wiring must be neat in appearance. All cabinet wiring must be continuous from its point of origin to its termination point. Butt type connections/splices are not acceptable. All cabinet back panel conductors must be soldered, at its destination point as specified. Printed circuit boards, except for BIU rack and pedestrian isolation boards, must not be used on main panels.

3.108 All connecting cables and wire runs must be secured by mechanical clamps. Stick-on type clamps are not acceptable.

3.109 The grounding system in the cabinet must be divided into three separate circuits (AC Neutral, Earth Ground, and Logic Ground). These ground circuits must **NOT** be connected together at a single point as outlined in the NEMA TS 2 Standard.

3.110 All pedestrian push-button inputs from the field to the controller must be opto-isolated and operate at 12 VAC.

3.111 All wire (size 16 AWG or smaller) at solder joints must be hooked or looped around the eyelet or terminal prior to soldering to ensure circuit integrity. Lap joint soldering is not acceptable. All connections to other than solder connections must be made with insulated spade connectors.

3.112 All exposed or protruding 120 VAC terminals or screws must be covered or shielded to prevent shock hazard to personnel.

3.113 All conductors used in cabinet wiring must be identified by the use of a pre-printed sleeve or wire marker clearly visible and before attachment to a lug, terminal or making a connection. All unused wires must be terminated and

labeled at a terminal strip. The tying back of unused wires is not acceptable. All wiring harnesses must be encased in a continuous mesh sheath. The use of cable ties to arrange wiring harnesses is not acceptable. All conductors and wiring harnesses must be routed and arranged to allow easy access to all equipment and terminals.

3.114 The main panel must incorporate a relay to remove +24VCD from the common side of the load switches when the intersection is placed into flash. The main panel must incorporate a relay or interlock that will initiate stop time to the controller on ring 1 and ring 2 whenever the intersection goes into a "conflict flash" condition. The relays mention above must be Potter & Brumfield, Model KRAP-N11AG-120V or approved equal.

3.115 **Power Panel Design And Construction**

3.116 The power panel must consist of a separate, fully enclosed module, securely fastened to the lower right side wall of the cabinet. The power panel must be wired to provide the necessary power to the cabinet, controller, Malfunction Management Unit, cabinet power supply and auxiliary equipment. It must be manufactured from 0.090 inch, 5052-H32 aluminum with removable plastic front cover. Means must be provided to allow access to the main and auxiliary breakers without removing the front cover. All components of the power panel must be accessible for ease of replacement without removing any other components or equipment. Adequate space between components must be provided for the tightening of all terminals.

3.117 The power panel must be identical for all cabinets except for breaker sizing. The power panel must house the following components:

3.118 All circuit breakers must be single pole Square-D or approved equivalent and supplied in a Q.O.U. mounting. The main breaker must be labeled "MAIN". A 30-amp main breaker for 12-position cabinets and a 40-amp breaker for 16 position cabinets. This breaker must supply power to the controller, MMU, signals, cabinet power supply, isolation transformer, and separate breakers used to split the power feed and auxiliary panels. Breakers must be thermal magnetic type, UL listed for HACR service, with a minimum of 10,000 amp interrupting capacity. All breakers must be installed in a vertical orientation.

3.119 One (1) single pole fifteen-amp (15-amp) breaker labeled "Auxiliary" must supply power to the fans, lights and GFCI outlet. The power feed for this breaker must not be fed from the load side of the main breaker but will be fed from the main feed side.

3.120 One (1) single pole fifteen amp (15-amp) breaker must supply power to a SOLA CVS SERIES CONSTANT VOLTAGE TRANSFORMER TYPE 23- 23-125-8 which must be called (isolation transformer) throughout these specifications. No substitution must be allowed. The isolation transformer must be mounted inside the cabinet on the right side of the cabinet wall above the power panel. This breaker must be labeled "ELECTRONIC EQUIPMENT". The power feed for this breaker must be from the "line out equipment" side of the power line surge protector (EDCO Surrestor SHP-300-10). No substitute must be allowed. The "neutral equipment" side of

the same SHP-300-10 must be wired to the neutral input of the isolation transformer. The load side of the isolation transformer both AC+ and AC- (neutral) must power the Controller Unit, Malfunction Management Unit, Power Supply, and no other equipment.

3.121 A 50 amp, 125 VAC radio interference line filter.

3.122 A normally open, 60-amp, mercury contactor Durakool model BBC-7032 or exact equivalent.

3.123 One (1) Insulated AC Neutral bus bar with a minimum of twelve (12) positions capable of accepting three #12 wires per position.

3.124 One (1) Earth ground bus bar (chassis ground) with a minimum of seven (7) positions large enough to accept three #12 wires per position.

3.125 A NEMA type 5-15R GFCI convenience outlet wired as specified.

3.126 A six (6) position (minimum) terminal block must be provided for the termination of the AC+ Feed to the cabinet, the AC- Neutral Feed to the cabinet and the Earth Ground or (Chassis Ground) to the cabinet. A single hole compression lug capable of accepting as a minimum #10 AWG to a maximum #4 AWG wire must be provided for each termination. The compression lug must be a screwdriver slot type rated for copper wire. Four (4) terminal lugs must be provided for each cabinet. These lugs must be protected with a transparent cover. Means must be provided for installing or tighten the cabinet service feeds without removing the protective cover.

3.127 The AC neutral bus, earth ground bus and DC logic ground must "NOT" be electrically connected and must be electrically isolated from each other within the cabinet wiring in lieu of NEMA TS 2-1992 FIGURE 5.4.2-1 conductors indicated.

3.128 **Auxiliary Cabinet Equipment**

3.129 The cabinet must be provided with **two** thermostatically controlled (adjustable between 80-150 degrees Fahrenheit) ventilation fans in the top of the cabinet plenum. Each fan must be a ball bearing type fan and must be capable of drawing a minimum of 100 cubic feet of air per minute. The fans must have a minimum design life of one hundred thousand (100,000) hours. Each fan must have its own thermostat, fan and thermostat must be rated for one hundred and twenty-five percent (125%) of capacity. Each fan and thermostat assemble must be fused. All fuse holders must be of the encased type.

3.130 A 25-watt R-25 plated metallic gooseneck incandescent lamp fixture mounted on a 14-inch flexible arm must be included. The flexible arm must be permanently mounted on the lower right side to sufficiently illuminate the field terminals. A rotary type switch, used to activate this lamp must be provided and installed on the rear of the lamp housing. The lamp must be wired to a door-activated switch mounted near the top of the door. If the toggle switch is ON and the main door is closed the lamp will be off. If the rotary switch is ON and the main door is closed the lamp will be off.

3.131 A 25-watt R-25 plated metallic gooseneck incandescent lamp fixture mounted on a 14-inch flexible arm must be included. The flexible arm must be permanently mounted to the middle of the cabinet door. A rotary type switch, used to activate this lamp must be provided and installed on the rear

of the lamp housing. The lamp must be wired to a door-activated switch mounted near the top of the door. If the toggle switch is ON and the main door is closed the lamp will be off. If the rotary switch is ON and the main door is closed the lamp will be off.

3.132 A fluorescent lighting fixture must be mounted on the inside top of the cabinet near the front edge. The fixture must be rated to accommodate a F15T8 lamp operated from a normal power factor UL or ETL listed ballast. The fluorescent lighting fixture must be rapid start type and cold weather rated. The lamp must be wired to a door-activated switch mounted near the top of the door. If the main door is closed the lamp will be off.

3.133 A rigid slide-out document tray must be mounted below the bottom shelf. The tray must be of sufficient size and strength to hold a complete set of cabinet wiring drawings, intersection diagrams, equipment and programming manuals for all equipment and modules applicable to each cabinet. The tray must operate by sliding out, then opening a hinged cover to remove documents. After removing the documents and closing the cover, the tray must serve as a suitable resting place for documents or a laptop computer. See diagram concerning the design and construction of this tray. As a reference, use Hennesy Products Inc. Part No. 541.

3.134 Three- (3) sets of complete and accurate cabinet wiring drawings must be supplied with each cabinet.

3.135 One (1) set of manuals for the Controller Unit, Malfunction Management Unit, Power Supply, Detector Rack, Vehicle Detector Amplifier modules must be supplied with each cabinet.

3.136 Ten complete sets of schematics, logic drawings, and assembly drawings for each type of electronic unit supplied i.e. Controller Unit, MMU, Power Supply, Load Switches, and Flashers. This documentation must be provided prior to the delivery of any equipment and must be a one-time shipment.

3.137 Two complete copies of component, hardware, and manufacturer indices of every item, unit, assemble and component within a cabinet, must be included as part of these specifications. A complete listing of replacement parts and cost must be included.

3.138 **Vehicle Detection**

3.139 A vehicle detector amplifier rack(s) must be provided in each cabinet. Detector racks must be available in two configurations.

3.140 Configuration #1 - Must support 16 channels of loop detection, and one BIU contained within one (1) Detector Rack. Configuration #1 must be installed into all Size (5) cabinets

3.141 Configuration #2 - Must support two (2) Detector Racks with 16 channels of loop detection each, and one BIU contained within each rack. Configuration #2 must be installed into all Size (6) cabinets.

3.142 Each cabinet must contain detector interface panels for the purpose of connecting field loops and vehicle detector amplifiers. One 16-position interface panel must be provided for each 16-channel detector rack per cabinet. The interface panel(s) must be attached to the lower left side wall of the cabinet. 6.4 Each interface panel must allow for the connection of a minimum of sixteen independent field loops. A ground bus terminal must be provided between each loop pair terminal to provide a termination for the loop lead-in ground wire. Detector Terminals must be screw type, Compression type termination must not be acceptable

3.143 All interface panels must be provided with lightning protective devices for all channels. All interface panels must be provided with EDCO SRA-6 or approved equal lightning protective devices for all available inputs.

3.144 A cable consisting of 20 AWG twisted pair wires must be provided to enable connection to and from the panel to a detector rack.

3.145 All termination points must be identified by a unique number and silk-screened on the panel.

3.146 Each detector rack must contain four (4) four channel vehicle detectors and detector amplifier that are compatible with conventional loops as well as 3M Microloop probes. These amplifiers must be 3M C424T Loop Detectors. Substitutes must not be accepted. All detectors must be interchangeable from detector rack to detector rack and from slot to slot without modification.

3.147 Each detector rack must be powered by the cabinet power supply.

3.148 **Cabinet Auxiliary Switch Panel And Police Panel**

3.149 An auxiliary switch panel must be mounted on the inside of the main door. The auxiliary switch panel must provide as a minimum the following:

3.150 **AUTO/FLASH SWITCH**. When in the FLASH position, power must be maintained to the controller and the intersection must be placed in flash. The controller must not be stop timed when in flash. When the switch is moved from FLASH position to the AUTO position, an external start signal must be applied to the controller. This external start signal will force the controller to initiate the start up sequence when exiting flash.

3.151 **STOP TIME ON/OFF SWITCH.** STOP TIME ON position, when applied, the controller must be stop timed in the current interval.

3.152 C**ONTROL EQUIPMENT POWER ON/OFF SWITCH**. This switch must control the Controller Unit, Malfunction Management Unit and Power Supply AC power. When in the ON position the AC power must be applied.

3.153 Two (2) spare switch positions holes must be provided and plugged for future use.

3.154 The police door switch panel must contain the following:

3.154.1 **AUTO/FLASH SWITCH.** When in the FLASH position, power must be maintained to the controller and stop time must be applied. The intersection must be placed in flash. When the switch is moved from FLASH position to the AUTO position, an external start signal must be applied to the controller. This will force the controller to initiate the start up sequence when exiting flash.

3.154.2 **SIGNALS ON/OFF SWITCH.** When in the SIGNALS OFF position, power must be removed from all signal heads in the intersection. The MMU must not conflict or require reset.

3.154.3 **AUTO/MANUAL SWITCH.** Cabinet wiring must include provisions for an AUTO/MANUAL toggle switch and a six (6') foot hand cord. A legend, knockout for the toggle switch and terminals for a hand cord must be provided. All knockouts must be plugged. The switch must be in the top position in the AUTO mode. The AUTO/MANUAL switch and hand cord must not be provided unless it is called for in the special provisions of this specification.

3.155 All toggle type switches must be heavy duty and rated 15 amps, at a minimum. Single or double-pole switches may be provided, as required.

3.156 Any exposed terminals or switch solder points must be covered with a non-flexible shield to prevent accidental contact.

3.157 All switch functions must be permanently and clearly labeled. All wire routed to the police panel and auxiliary panel must be adequately protected again damage from repetitive opening and closing of the main door. No modular connectors will be allowed in the cabinet except for the detector panel interface. All other cabinet wiring must be "hard wired" point to point.

3.158 **Controller Telemetry Interface Panel**

3.159 A telemetry interface harness and panel must be supplied with each cabinet.

3.160 The harness must be a minimum of 6 feet long and must consist of two twisted shielded pairs, 22 AWG wire with drain wire in an overall jacket, terminated to a 9-pin "D" type connector at one end. The pin out of the 9-pin connector must be in exact accordance with the NEMA TS 2 Standard. The opposite end of the harness must be terminated on a 10-position EDCO PCB-1B or exact equal lightning protection socket base.

3.161 All terminal block designations and peripheral board-mounted components must be labeled as to their number and function and must correspond to the cabinet wiring diagrams.

3.162 The following signals must be accessible from the telemetry interface panel:

3.162.1 Local controller command lines 1 & 2.
3.162.2 Local controller read-back lines 1 & 2.
3.162.3 Master controller command lines 1 & 2.
3.162.4 Master controller read-back lines 1 & 2.
3.162.5 Earth grounds

3.163 A socket mounted communication line transient protection device must be supplied with the telemetry interface panel. The device must be an EDCO model PC642C-008D or exact approved equivalent. The transient protection device must be wired in series with the telemetry communication circuit.

3.164 A socket mounted communication line transient protection device must be supplied with the telemetry interface panel. The device must be an EDCO model PC642C-008D or exact approved equivalent. The transient protection device must be wired in series with the telemetry communication circuit.

3.165 Communication line impedance must be matched to the transmitter output impedance to minimize noise on the communication lines. The panel must allow connection of a 620 ohm resistor across the command and read-back lines, where necessary.

3.166 **Preempt And Coordination Interface Panel**

3.167 All cabinets with a Type 2 Main Panel must have a Preempt and Coordination panel mounted on an inside cabinet wall. This panel must have a harness and connector that will mate with a connector on the Control Unit and will access the following minimum input/output functions. This is also known as the "D" Connector, Panel and Harness Assembly.

INPUT		**OUTPUT**
TBC on line		Preempt No. 1 Status
Preempt No. 1		Preempt No. 2 Status
Preempt No. 2		Preempt No. 3 Status

Timing Plan A		Preempt No. 4 Status
Timing Plan B		Preempt No. 5 Status
Timing Plan C		Preempt No. 6 Status
Timing Plan D		Timing Plan A
Offset No. 1		Timing Plan B
Offset No. 2		Timing Plan C
Offset No. 3		Timing Plan D
Alternate Sequence A		Offset No. 1
Alternate Sequence B		Offset No. 2
Alternate Sequence C		Offset No. 3
Alternate Sequence D		Automatic Flash
Dimming Enable		TBC Auxiliary No. 1 through No. 3
Automatic Flash		Free/Coord Status

3.168 **Auxiliary Devices**

3.169 **Load Switches**

3.169.1 Load switches must be solid state and must conform to the requirements of Section 6.2 of the NEMA TS 2 Standard or as specified.

3.169.2 Signal load switches must have a minimum load current rating of 10 amperes at 120 VAC for incandescent lamp load.

3.169.3 The front of the load switch must embody a minimum of six LED indicators. Three indicators to show the input to the

load switch and three indicators to show the output of the load switch.

3.169.4 Load switches must be dedicated per phase. The use of load switches for other partial phases is not acceptable.

3.169.5 The full supplement of load switches must be supplied with each cabinet to allow for maximum phase utilization for which the cabinet is designed.

3.170 **Flashers**

3.170.1 The flasher must be solid state design and must conform to the requirements of section 6.3 of the NEMA TS 2 Standard.

3.170.2 Flashing of field circuits for the purpose of intersection flash must be accomplished by a separate flasher.

3.170.3 The flasher must be rated at 15 amperes, double pole with a nominal flash rate of 60 FPM.

3.171 **Flash Transfer Relays**

3.171.1 All flash transfer relays must meet the requirements of Section 6.4 of the NEMA TS 2 Standard or as specified. Contacts must be capable of making, breaking, with a contact current rating of twenty (20) amperes.

3.171.2 The coil of the flash transfer relay must be de-energized for flash operation.

3.171.3 The full complement of flash transfer relays must be supplied with each cabinet to allow for maximum phase utilization for which the cabinet is designed.

3.172 **Malfunction Management Units**

3.172.1 Each cabinet assembly must be supplied with one Malfunction Management Unit (MMU) as defined by the requirements of Section 4 of the NEMA TS 2-1992 Standard.

3.172.2 Malfunction Management Units must be a Type 16.

3.173 **Bus Interface Units**

3.173.1 All Bus Interface Units (BIU's) must meet the requirements of Section 8 of the NEMA TS 2-1992 Standard.

3.173.2 The full complement of Bus Interface Units must be supplied with each cabinet to allow for maximum phase and function utilization for which the cabinet is designed.

3.173.3 Each Bus Interface Unit must include power on, transmit and valid data indicators. All indicators must be LED’s.

3.174 **Cabinet Power Supply**

3.174.1 The cabinet power supply must meet the requirements of Section 5.3.5 of the NEMA TS 2 Standard.

3.174.2 The cabinet power supply must provide LED indicators for the line frequency, 12 VDC, 12 VAC, and 24 VDC outputs.

3.174.3 The cabinet power supply must provide (on the front panel) jack plugs for access to the +24 VDC for test purposes.

3.174.4 One (1) power supply must be supplied with each cabinet assembly.

3.175 **Relay Package**

3.176 Relay Packages provided in all cabinets must meet the provisions as outlined in this section.

3.176.1 All relays must be Potter & Brumfield Type KRPA-N11AG-120V with indicator lamp wired in parallel with the coil.

3.176.2 All relay sockets must be Potter & Brumfield Type 27E891-din rail mount, with screw terminals.

3.176.3 All relay sockets must be mounted on a single Din Rail with appropriate mounting hardware. A minimum of eight (8) sockets and relays must be provided in each cabinet.

3.176.4 All relays must be clearly label, and mounted as follows from left to right:

3.176.4.1 CR1 PRE-EMPT 1
3.176.4.2 CR2 PRE-EMPT 2
3.176.4.3 CR3 REMOTE FLASH
3.176.4.4 CR4 INHIBIT MAX
3.176.4.5 CR5 SPECIAL FUNCTION
3.176.4.6 CR6 EMERGENCY FLASH
3.176.4.7 CR7 STOP TIMING
3.176.4.8 CR8 SPARE

3.176.5 Immediately below the Relay Package must be mounted a six (6) position (minimum) fuse block capable of accepting appropriate 120 volt buss fuses from 1/4 amp to 20 amperes. A five (5) ampere slow-blow fuses must be provided in each fuse holder. A clear plastic cover must be provided over the fuse block to protect personnel from electrical shock. The Fuse block must be numbered from left to right starting with FU1 through FU6. AC+ must be wired to the top of fuse FU1 and to no others. The source of AC+ must be from the AC+ signal bus and must have 120VAC power as long as the intersection is in color operation. If a flash condition exists, either MUTCD flash, conflict flash, police panel or auxiliary flash AC+ power to FU 1 must be removed. Each fuse block must use screw terminals for wire termination, soldered terminals are not acceptable.

3.176.6 Immediately below the Relay Package must be mounted a six (6) position (minimum) fuse block capable of accepting appropriate 120-volt buss fuses from 1/4 amp to 20 amperes. A five (5) ampere slow-blow fuses must be provided in each fuse holder. A clear plastic cover must be provided over the fuse block to protect personnel from electrical shock. The Fuse block must be numbered from left to right starting with FU1 through FU6. AC+ must be wired to the top of fuse FU1 and to no others. The source of AC+ must be from the AC+ signal bus and must have 120VAC power as long as the

intersection is in color operation. If a flash condition exists, either MUTCD flash, conflict flash, police panel or auxiliary flash AC+ power to FU 1 must be removed. Each fuse block must use screw terminals for wire termination, soldered terminals are not acceptable.

3.177 All relays must be wired as per this explanation and diagram provided.

3.177.1**Pre-Empt 1**

3.177.1.1CR1 terminal #1 must be wired to Logic Common.

3.177.1.2CR1 terminal #2 must be wired to AC-neutral.

3.177.1.3 CR1 terminal #3 must be wired to I/O Pre-empt input #1.

3.177.1.4CR1 terminal #7 must be wired to the top of fuse FU2.

3.177.2**Pre-Empt 2**

3.177.2.1CR2 terminal #1 must be wired to Logic Common.

3.177.2.2CR2 terminal #2 must be wired to AC-neutral.

3.177.2.3CR2 terminal #3 must be wired to I/O Pre-empt input #2.

3.177.2.4CR2 terminal #7 must be wired to the top of fuse FU4.

3.177.3 **Remote Flash**

3.177.3.1 CR3 terminal #1 must be wired to Logic Common.

3.177.3.2 CR3 terminal #2 must be wired to AC-neutral.

3.177.3.3 CR3 terminal #3 must be wired to I/O Test Input B which must initiate Automatic flash per NEMA T 2-1992 section 3.9.1.2(1).

3.177.4 **Inhibit Max.**

3.177.4.1CR4 terminal #1 must be wired to Lau terminal #62.

3.177.4.2CR4 terminal #2 must be wired to AC-neutral.

3.177.4.3CR4 terminal #3 must be wired to I/O terminals.

3.177.4.4Inhibit Max Ring I and Inhibit Max Ring II.

3.177.5 **Special Function**

3.177.5.1CR5 terminal #2 must be wired to AC-neutral.

Montgomery County personnel will be responsible for any further wiring to this relay

3.177.6**Emergency Flash**

3.177.6.1 CR6 terminal #1 must be wired to Logic Common.

3.177.6.2 CR6 terminal #2 must be wired to AC- neutral.

3.177.6.3 CR6 terminal #3 must be wired to I/O terminals.

3.177.6.4 Stop Time Ring I and Stop Time Ring II.

3.177.6.5 CR6 terminal #5 must be wired to MMU Connector A Pin W. (output relay 1 common).

3.177.6.6 CR6 terminal #7 must be wired to Lau terminal #59.

3.177.6.7 CR6 terminal #8 must be wired to the load side of the Line Filter or terminal connected to Line Filter.

3.177.6.8 If this relay is removed the intersection must immediately go to flash.

3.177.6.9 Upon activation of this relay the intersection must immediately go to flash.

3.177.6.10 An external restart must be applied to the controller when the intersection is returned to color operation.

3.177.7 **Stop Time**

3.177.7.1 CR7 terminal #1 must be wired to Logic Common.

3.177.7.2 CR7 terminal #2 must be wired to AC- neutral.

3.177.7.3 CR7 terminal #3 must be wired to I/O terminals.

3.177.7.4 Stop Time Ring I and Stop Time Ring II.

3.177.7.5 CR7 terminal #7 must be wired to Lau terminal #60.

3.177.8 **Testing**

3.177.9 Each Controller, MMU, Power Supply, Detector Rack, Detector Modules, BIU's And cabinet assembly must be tested as a complete entity under signal load for a minimum of 24 hours.

3.177.10 Each assembly must be delivered with a signed document detailing the cabinet final tests performed.

3.177.11 The cabinet must be assembled and tested by the controller manufacturer or authorized local distributor to ensure proper component integration and operation.

3.177.12 Montgomery County reserves the right to reject an entire shipment of cabinets, units, or devices covered by

this Specification or more prove to be defective with in a thirty (30) day period after shipment, or fail any performance test.

3.178 Electronic components must be warranted by the manufacturer against mechanical and electrical defects for a period of 2 years. The cabinet assembly and all of its component parts must be warranted for a period of one year. The manufacturer's warranty must be supplied in writing with each cabinet, and unit within the cabinet. Second party extended warranties is not acceptable.

3.179 Any defects in the design, workmanship, or material must be fully corrected by the supplier during the warranty period at no cost to the owner. All costs of labor parts and transportation to and from vender must be borne by the vender for the duration of the warranty period.

3.180 The vendor must provide all revisions to any equipment furnished under these specifications, at no cost to Montgomery County.

3.181 **Shipping And Handling**

3.182 The contractor must deliver the cabinets to Montgomery County, Signal Unit, Building "C", 1283 Seven Locks Road, Rockville, Maryland, 20854. The contractor must notify the signal unit (240) 773-3700 at least seven (7) calendar days in advance of delivery and unloading of any shipment to verify the delivery date and location. No more than two (2) trailer loads must be accepted per day and then only on County workdays, between the hours of 7:00 a.m. and 1:00 p.m.

3.183 All cabinets must be shipped mounted on skids constructed to fit the cabinet to be transported. Skids must be fabricated from new materials only. The use of recycled materials in the manufacturing of the skids is unacceptable. The bottom of the cabinets must be sealed when attached to the skid and a 3.5 inches clearance must be provided between the bottom of the skid and the floor. Additionally, the cabinet must be banded to the skid from front to back and side to side.

3.184 All cabinets must be provided with their full complement of equipment inside each cabinet. All equipment must be boxed and protected for shipment. All documentation must be provided in each cabinet as outlined in these specifications. If size constraints prohibit the shipment of equipment inside the cabinet, the following alternative may be used. Each cabinet must be labeled with a box number. The same box number must be applied to each box of equipment or documentation belonging to that cabinet.

3.185 Serial numbers, model numbers and the manufacturer's name and production date must be clearly legible and permanently placed on all cabinets, Controller Units, assemblies, MMU's, Power Supplies, BIU's, Detector racks, all equipment and modules supplied, and circuit boards.

3.186 All other equipment, assemblies and documentation must be shipped separately and in their own containers or boxes. No unlike unit(s) or item(s) must be shipped together in a single container.

F. ACCESSIPLE PEDESTRAIN SIGNALS (APS)

4.0 This item consists of furnishing and installing MSHA standard accessible pedestrian signals (APS). Each APS must consist of an interactive pedestrian pushbutton with speaker, an informational sign, a solid-state electronic interface unit, a power supply, wiring, and mounting hardware. The APS must meet the requirements of the MUTCD and as modified herein.

5.0 Electrical Requirements.

6.0 The APS must operate with systems providing 95 to 130 VAC, 60 Hz and throughout an ambient air temperature range of –29 to +160 °F (-34 to +70 °C). The APS must contain a power protection circuit consisting of both fuse and transient protection.

7.0 Audible Indications.

7.1 A pushbutton locator tone must sound at each pushbutton.

7.2 A clear, verbal message must be used to communicate the pedestrian walk interval.

7.3 This message must sound throughout the WALK interval only. The verbal message must be “WALK SIGN”, which may be followed by the name of the street to be crossed. No other messages must be used to denote the WALK interval.

8.0 Automatic volume adjustments in response to ambient traffic sound level must be provide up to a maximum volume of 89 dB. Locator tone and verbal messages must be no more than 5 dB louder than ambient sound.

9.0 Pedestrian Pushbutton must be at least 2 in. (50 mm) in diameter or width. The force required to activate the pushbutton must be no greater than 3.5 lb (15.5 N).

10.0 If a pushbutton is depressed for three seconds, a custom verbal message must be given before the walk cycle goes into effect which tells the pedestrian their location or other pertinent information about the intersection.

11.0 A red-light emitting diode (LED) must be located on or near the pushbutton which, when activated, acknowledges the pedestrians request to cross the street.

12.0 A sign must be located immediately above the pedestrian pushbutton and parallel to the crosswalk controlled by the pushbutton.

13.0 Tactile Arrow. A tactile arrow, pointing in the direction of travel controlled by a pushbutton, must be provided either on the pushbutton or its sign. This arrow must meet the requirements of Section X02.5.1.4 of the U.S. Access Board’s “Public Rights-of-way Access Advisory Committee Report, 2001”.

14.0 Vibrotactile Feature. A vibrotactile messages must also be provided at each pedestrian pushbutton. The pushbutton must pulse when depressed and must vibrate continuously throughout the WALK interval.

G. VOICE-GRADE COMMUNICATIONS CABLE

1.0 This item must consist of furnishing and installing voice-grade, twisted-pairs telephone-type communications cable of the size and type as shown on the Plans and as specified in these Special Provisions, or as directed by the Engineer, in underground conduit, conduit risers, and overhead, complete with all necessary hardware as required.

2.0 Cable supplied under this item must be "Figure Eight" type self-supporting Voice-Grade (22 AWG) Communication cable with integral messenger cable for overhead installation. The cable must meet all applicable requirements of IMSA Specification #60-4 (1991). It must be polyethylene insulated, polyethylene jacketed, copper shielded, and jelly filled as per the IMSA Specification. The number of twisted pairs of #22 AWG, insulated, solid copper conductors must be as specified on the Plans.

3.0 Note Every 10th pole, top of riser, and 'Dead End' must be properly grounded.

4.0 Underground Duct Voice-Grade Communication Cable (22 AWG) must meet all applicable requirements of IMSA Specification #60-2 (1991). It must be polyethylene insulated, polyethylene jacketed, copper shielded, and jelly filled as per the IMSA Specification. The number of twisted pairs of #22 AWG, insulated, solid copper conductors must be as specified on the Plans.

5.0 Supporting Hardware:

6.0 Standard telecommunication industry, non-corroding hardware must be used to attach the cable to utility or other poles for overhead installation. Cable suspension clamps must be designed for "Figure Eight" cable, must have a "J-hook" for installation convenience and must include a thru-bolt of the size and length required by the utility company. The suspension clamp must be appropriate to the "turning angle" of the cable at that point of the installation, including the use of corner suspension clamps where necessary. Dead ends must be used as necessary.

7.0 Where required, all conduit supplied must be in accordance with the Specifications the specification in section C.

8.0 The Engineer reserves the right to require the Contractor to provide certification that the cable to be supplied will meet the above specifications, or to provide catalog cuts or other literature, prior to furnishing the cable.

9.0 Communication cable must be installed where, and in the manner indicated on the Plans, or as directed by the Engineer. Disconnecting and splicing of interconnect cable must be performed by Montgomery County Forces. The contractor must run the interconnect cable into the base of each cabinet and properly tag the cable.

10.0 communication cable will be installed underground, in polyvinyl chloride electrical conduit.

11.0 Overhead installation may be used, using the self-supporting cable intended for such installation.

12.0 Cables must be attached to utility poles by means of standard hardware as shown on the Plans and in accordance with the requirements of the owner.

13.0 Attachments to utility poles must be made a minimum of ten (10) feet below primary electrical cables or other facilities carrying 750 volts or more. A minimum vertical clearance of eighteen (18) feet above Interstate highway roadway traversed by overhead communications cable must be maintained.
14.0 Vertical cable runs mounted on the outside of poles must be installed in risers as specified in the Plans.
15.0 Where shown on the Plans, communications cable may be installed overhead between an interconnect cabinet and a controller cabinet via existing strain poles and signal span wire. The locations involved are shown on the Plans.
16.0 The cables specified in 1.1 and 1.2 above may be used with either low voltage telephone-level signals or may be used with 115 VAC interconnection circuits.
17.0 Splices in communications cable must be made only at terminal blocks in cabinets. No splices must be allowed in pull boxes or anywhere overhead. Generally, County Forces must be responsible for splicing of communication cable.
18.0 Connection: Communications cable must be properly connected at the controller cabinets, sampling equipment cabinets and interconnect cabinets, for correct and accurate transmission of data between these points.
19.0 Weather service heads must be used wherever the cable directly enters a strain pole or a vertical conduit run.
20.0 Drip loops of at least eight (8) inches must be provided at all overhead entrance points such as strain poles and vertical conduits.
21.0 Slack must be provided at pull boxes, splice boxes, interconnect cabinets, controller cabinets, and other junction points. Ten (10) feet of cable slack must be provided, neatly coiled-off, tied and positioned in the bottom of the enclosure.