SECTION 1073 -- ROADWAY LIGHTING, SIGN LIGHTING, AND TRAFFIC SIGNALS

1073.01 -- Description

This Section describes material requirements for roadway lighting, sign lighting, and traffic signals.

1073.02 -- Material Characteristics

1. General Requirements:

a. All materials shall be new. Used or reconditioned equipment is not acceptable.

b. Materials scheduled for use on the project must be approved by the Engineer before they can be installed.

c. (1) The Contractor shall be prepared to furnish, upon request, a sample of any item or material that he/she proposes to furnish. Unless destructive testing is required, the sample will be returned.

(2) All costs related to the furnishing of samples, including all shipping and testing costs, shall be included in the contract bid price.

d. Review of shop drawings by the Engineer is for the purpose of checking for general conformance with the design concept of the project and for general compliance with the contract documents only. Any action taken by the Engineer on submittals and shop drawings will not relieve the Contractor of the responsibility to provide satisfactory materials and equipment meeting the requirements of the contract documents.

e. If errors in shop drawings are not detected by the Engineer, the Contractor is not relieved of his/her responsibility to comply with the contract documents; and the Engineer's review of the shop drawings shall never be construed to allow the Contractor to proceed in error.

f. At the time of each submittal, the Contractor shall, in writing, call the Engineer's attention to any deviations that the shop drawings or samples may have from the requirements of the contract documents.

2. Ground Rods:

a. Ground rods shall, with the exception of length and diameter, be in compliance with IMSA Specification No. 62 and be installed in accordance with Article 250 of the *National Electric Code*. Ground rods used in traffic signal installations shall extend through the foundation and at least 2.1 m into the ground with 125 mm extending above the foundation. Ground rods shall have a minimum diameter of 13 mm. Ground rods shall be supplied with a ground rod clamp.

b. Ground rods used in roadway lighting installations shall comply with ANSI/UL 467 (ANSI C 33.8 and CSA) and IMSA Specification No. 62 and be installed in accordance with Article 250 of the *National Electric Code* and the project plans.

3. Electrical Conduit and Duct Systems:

a. Metallic conduits of the various types shall conform to the applicable industry standards as follows:

(1) Galvanized rigid steel (GRS) conduit shall meet the requirements of the *NEC* Article 346 and Underwriters Laboratories UL-6.

(2) Intermediate metallic conduit (IMC) shall meet the requirements of the *NEC* Article 345 and UL-1242.

(3) Electrical metallic tubing (EMT) shall meet the requirements of the *NEC* Article 348 and UL-797.

b. Non-metallic conduits of the various types shall conform to the applicable industry standards as follows:

(1) Polyvinyl chloride (PVC) conduit shall be rigid PVC conduit, schedule 40, and shall meet the requirements of the *NEC* Article 347, NEMA TC-2, and UL-651.

(2) Filament reinforced epoxy conduit (FRE) shall be specification grade and shall comply with Article 347.1 of the *NEC* and shall be UL listed.

(3) Polyethylene (PE) conduit shall be smooth wall, coilable duct of Type III, Grade 34, Class C, Category 5 High Density polyethylene (HDPE) in accordance with the latest edition of ASTM D 1248. The polyethylene conduit shall be manufactured in accordance with ASTM D 3485 and NEMA TC-7.

c. Cable in duct (CID) systems shall be factory assembled in smooth wall, coilable HDPE duct of the type specified above. Conductors shall be of the type, size, and number called for in the plans. All conductors shall be prelubricated before being inserted into the duct and the ends of the duct shall be sealed.

d. Fittings used with metallic conduit shall be of a compatible metal. Fittings and cement used with plastic conduit must be compatible with the conduit material.

e. Conduit sizes required are shown in the plans and shall be interpreted to mean the minimum "trade size" allowed for the application. The Contractor may, at his/her option and expense, substitute a larger size.

4. Breakaway Devices:

a. Breakaway devices shall conform to all current AASHTO requirements for energy absorption and structural design.

b. Breakaway devices shall be furnished complete with the necessary hardware to provide a complete installation.

c. Galvanizing requirements for steel breakaway devices shall be in accordance with ASTM A 123.

5. Conventional Light Poles (Up to 15 m Mounting Height):

a. Light poles, anchor bolts, and all accessory hardware must comply with the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*. The shaft shall be a single section and shall have only one longitudinal, automatically and electrically welded joint. Shafts for poles of 13.7 m or 15.2 m mounting height may be two-piece if approved by the Engineer.

The pole and mast arm assemblies shall be galvanized in accordance with ASTM A 123 or A 153, as applicable. All burrs, flash, and sharp edges internal to the pole and mast arm assemblies shall be removed.

b. All poles shall have an identification number stamped into the top of the base plate (see plans for details). Letter height shall be 12 mm. The identification number shall contain the pole type and size, the mast arm type and size, date of manufacture, and manufacturer's name.

c. (1) Connecting bolts for use with power-installed foundations shall be supplied by the foundation manufacturer.

(2) The bolts shall be galvanized.

(3) All other anchor bolts are detailed in the plans.

d. Each pole shall be furnished complete with an approved grounding nut or lug. The grounding nut or lug shall be welded inside the shaft opposite the handhole and accessible through the handhole.

e. The Contractor shall furnish detailed drawings to the Engineer for approval. A certificate of compliance from the manufacturer stating that the poles and associated materials comply with the structural, wind loading, and galvanizing requirements is required.

6. High Mast Lighting Towers (Poles Over 15 m in Mounting Height):

a. High mast towers, anchor bolts, and accessory hardware must comply with the AASHTO *Standard Specifications for Structural Supports For Highway Signs, Luminaires and Traffic Signals*.

b. Unless stated otherwise in the plans or special provisions, each high mast tower will be furnished complete with base, handhole, anchor bolts, and lowering system with internal motor. All items must be compatible and work together to provide a reliable and efficient lighting unit.

c. The tower shall be of sectional construction, either round or multi-sided polygon in cross section, and shall be fabricated of high strength, low alloy steel. Each individual pole section shall contain no more than 2 longitudinal welds and no transverse or circumferential splices, either mechanical or welded. Each section shall be galvanized after fabrication. Each section shall be uniformly tapered and shall be joined by slip fit or telescoping joints. The overlap length of the joints shall be a minimum of 1 1/2 times the outside diameter measured at the end of the male section. The pole shaft shall have a single access door providing access to the winch, cable, cable drum(s), and electrical components. The door opening shall be reinforced to maintain the original strength of the pole. The door shall be mounted with a stainless steel loose joint butt hinge and a padlock hasp for securing.

d. Each tower shall be furnished complete with an approved grounding nut or lug located at points 90 degrees and 270 degrees from the handhole and readily accessible through the handhole.

e. The pole shall be provided with an integrally-welded base plate using steel that meets or exceeds the specifications of the adjacent pole section. The base plate shall be drilled for the required anchor bolts. The surface around each hole shall be milled flat and smooth to receive the anchor bolt nut. The plate shall be attached to the shaft with 100% penetration circumferential welds.

f. The base plate shall be designed to be supported and secured solely by nuts. The space between the base plate and foundation shall be left ungrouted and will be enclosed with expanded aluminum mesh. The pole top shall be designed to support the head assembly of the lowering system. Drawings shall be provided with the pole which show assembly sequence, lift point, and recommended erection procedure. The pole and lowering system shall be compatible. No field welding will be allowed in the assembly of the shaft. All sections of the shaft will be match-marked to facilitate assembly and to ensure that each shaft is assembled with the proper tapered sections.

g. Anchor bolts shall be provided by the tower manufacturer. Each anchor bolt shall be provided with one leveling nut, one hold-down nut, and two high-strength steel flat washers. The nuts, washers, and the top 300 mm of the anchor bolt shall be galvanized.

h. (1) The high mast lowering system (head assembly, luminaire ring, terminal block, cable drums, winch assembly, internal power unit, support and electrical cables, and electrical components) will be on the NDR Approved Products List.

(2) The light ring and lowering system shall be capable of supporting 12 fixtures but shall be designed to physically hold the number of fixtures shown on the plans for the particular tower in question.

i. The tower shall be supplied with lightning protection. This shall include lightning rod (air terminal), lightning arrestor, and all necessary grounding connections.

j. The manufacturer shall supply all drawings, installation instructions, maintenance manuals, and technical information required for the proper installation and maintenance of a complete operating assembly.

k. A manufacturer's representative shall be present, on site, to advise the Contractor during the installation of at least one complete tower. The duties of the manufacturer's representative shall include, but are not limited to, the following:

(1) Directing all adjustments to the lowering system to insure positive latching and unlatching. (This will consist of a minimum of 3 complete raising and lowering cycles.)

(2) Educating the maintaining utility or government agency in:

(i) The methods of proper maintenance to avoid hoist malfunctions.

(ii) The proper procedures to follow in the event of a hoist malfunction.

l. No deviations, substitutions, additions, or omissions from this *Specification* will be allowed without the lighting Engineer's approval. The lighting Engineer's decision in this matter will be final.

7. Roadway Lighting Luminaires: (Conventional and High Mast):

a. Roadway lighting luminaires and lamps acceptable for use on State projects will be listed on the NDR Approved Products List.

b. Luminaire type, wattage, and ballast ratings shall be shown in the plans.

c. Luminaires shall be supplied with lamps.

d. Luminaires must meet the design parameters shown in the plans.

8. Lighting Control Center Components:

a. Components comprising the various types of lighting control centers acceptable for use on State projects will be listed on the NDR Approved Products List.

b. The lighting control center shall conform to the requirements shown in the plans.

9. Photoelectric Control:

a. Photoelectric controls acceptable for use on State projects will be listed on the NDR Approved Products List.

b. Photoelectric controls shall conform to the requirements shown in the plans.

10. Roadway and Sign Lighting Structures:

a. All roadway and sign lighting structures requiring galvanizing shall be galvanized in compliance with ASTM A 123 after fabrication and welding has been completed.

b. All hardware shall be galvanized in compliance with ASTM A 153.

11. Sign Lighting Luminaires:

a. Sign lighting luminaires and lamps acceptable for use on State projects will be listed on the NDR Approved Products List.

b. Luminaire, ballast, lamp dimensions, and ratings shall be as prescribed in the plans.

c. The luminaire shall be furnished completely assembled and ready for mounting, connecting, and lamping.

d. Luminaires shall be U.L. labeled and listed as "Suitable for Wet Locations."

12. Electrical Items: All electrical items for roadway and sign lighting, such as wire, circuit breakers, relays, conduit, cable, mounting hardware, wood poles, pipe clamps, and related electrical material, shall conform to the appropriate *National Electric Code* requirements.

13. Traffic Signal Cable:

a. The traffic signal cable shall be as shown in the plans and shall comply in all respects with the IMSA specification as follows:

Specification Reference	Use
19-1 or 20-1	General Use
19-3 or 20-3	Aerial Cable
19-5 or 20-5	Direct Burial Cable

b. (1) Acceptable alternatives to the above cable may be furnished providing the specific cable has been approved in writing by the office of the NDR Traffic Engineer before its installation.

(2) IMSA conductor color coding shall be used and will be provided by the use of base colored insulation.

(3) This coloring shall penetrate the full thickness of all the conductor insulation.

(4) "Color" coding by the use of words or numerals printed on the insulation will not be accepted.

14. Electrical Wire and Cable:

a. Conductors and cables used for the electrical service shall conform to the applicable portions of Articles 230, 310, and 338 of the *National Electrical Code (NEC)* as well as to the requirements of the plans and special provisions, and shall bear the U-L label.

b. The word "wire," when used in conjunction with roadway lighting, sign lighting, and traffic signals, shall be taken to mean a single electrical conductor, either bare or insulated.

c. The word "cable," when used in conjunction with roadway lighting, sign lighting, and traffic signals, shall be taken to mean an assembly of single electrical conductors insulated from each other but laid up together by being twisted around a central core.

d. The word "conductor," when used in conjunction with roadway lighting, sign lighting, and traffic signals, shall be taken to mean either a single conductor (wire) or assembly of individual conductors (cable) capable of transmitting electricity.

15. Aerial Cable:

Aerial cable (ACSR) shall meet or exceed the applicable sections of the following specifications:

a. ASTM B-232 Aluminum Conductors, Concentric-Lay-Stranded Coated Steel Reinforced (ACSR)

b. ANSI/CEA S-76-474

16. Detector Lead-in Cable:

The detector lead-in cable shall be polyethylene insulated, polyethylene jacketed cable conforming with the latest edition of IMSA Specification No. 50-2.

17. Loop Detector Wire:

The loop detector wire shall be stranded, insulated wire rated at 600 volts for use in an inductance loop detector or as a lead-in wire. The wire shall comply with IMSA Specification 51-5.

18. Traffic Signals:

a. Traffic signals shall be designed in die cast aluminum or polycarbonate sections. All sections shall be interchangeable and fit so they can be combined in a tier.

b. The mounting device, lens indications, and other modifications shall be as shown in the plans.

c. The reflector shall be parabolic in design.

d. Other parts of the optical system, including the lens lamp socket, reflector, and reflector holder, shall be designed as a whole system so as to eliminate the return of outside light rays which enter the unit.

e. All parts of the vehicle signals shall be in compliance with the ITE Report on Adjustable Face Vehicle Traffic Control Signal Heads, and all parts of the pedestrian signals shall be in compliance with the ITE Report on Adjustable Face Pedestrian Heads.

f. (1) The body, doors, visors, and backplates of the signals and all mounting accessories shall be colored flat black.

(2) Die cast aluminum sections shall be given 1 prime coat of metal primer and 2 coats of high quality flat black enamel.

(3) Dipping will not be allowed for any part of the enameling process.

(4) The color shall be completely impregnated in polycarbonate material, and scratches shall not expose uncolored material.

g. Visors shall be attached with attaching screws and designed in a manner such that the visor may be easily installed or removed from the signal head.

h. A terminal block shall be mounted in the back of the second section of the signal head. The terminal block for a standard 3-section face shall be a 4-position, -terminal, barrier-type strip.

i. Hardware hinges shall be enclosed and have solid non-corrosive metallic hinge pins. Doors shall be secured against gaskets with wing nut clamps.

j. All signals at each intersection shall be from one manufacturer unless otherwise approved by the Engineer.

19. Vehicle Signals:

a. All lenses shall be prismatic and long range. The lenses shall have a nominal diameter of 200 mm or 300 mm as indicated in the plans. All lenses shall be made of glass meeting the light transitivity and chromaticity standards established by ITE Standard for Adjustable Face Vehicle Traffic Control Signal Heads.

b. Each signal lens, with the exception of lenses for optically programmed sections, shall have a visor of a type normally described as a tunnel visor which encloses 75 percent of the lens circumference for the entire length of the visor.

c. Cutaway type visors shall be provided for each lens of optically programmed sections.

d. Vehicle signal heads shall be equipped with a one piece, vacuum formed backplate. The backplate shall provide a black field border, 125 mm wide, around the assembly. Backplates are not required on single section heads, on 3 or 4 way heads, or on pole mounted heads.

20. Pedestrian Signals:

a. Pedestrian signals shall consist of 1 or 2 signal sections with rectangular lenses and mounting attachments as shown in the plans.

b. The upper portion shall display an international "DON'T WALK" symbol, and the lower portion shall display an international "WALK" symbol.

c. The two sections shall be of such design and construction as to fit rigidly and securely together with or without a spacer. Any space shall be no more than 13.0 mm thick.

d. These signals are intended to operate with incandescent lamps.

e. The lenses shall be either sanded or prismatic lenses of nominal dimensions 200 mm x 200 mm or 300 mm x 300 mm as indicated in the plans.

f. The lenses shall be made of a vandal-resistant, polycarbonate or acrylic plastic.

g. The letters on these lenses shall be designed to produce the maximum legibility both day and night.

h. The "WALK" symbol shall be white, and the "DON'T WALK" symbol shall be orange.

i. Both messages shall be screened on the lenses with a material which will not crack or peel.

j. The background or field around both messages shall be black.

k. Each signal lens shall be equipped with a visor which encloses the top and both sides of the lens.

21. Optically Programmed Traffic Signal:

Optically programmed traffic signals shall be limited to those on the NDR Approved Products List.

22. Traffic Signal Lamps:

The traffic signal lamps shall be clear and operate at 120 volts with an 8000 hour minimum rated life. All lamps shall have brass bases. All lamps shall be 150 watt for the 300 mm signal sections and 116 watt for the 200 mm signal sections. All lamps for pedestrian signal heads shall be 116 watts.

23. Traffic Signal Controllers and Cabinets:

a. Traffic Signal Controllers shall be either solid state pre-timed, NEMA vehicle actuated, or Type 170 as indicated in the plans.

b. Solid state pre-timed controllers shall comply with all applicable sections of NEMA specification TS-1, including environmental and design standards. The controllers shall fulfill all functional requirements of electro-mechanical pre-timed controllers with the following additional features:

(1) 4 cycles.

(2) 3 offsets per cycle.

(3) 3 splits per cycle.

(4) 24 intervals per split.

(5) 24 signal circuits minimum.

(6) 4 signal plans.

(7) 3 pre-emption sequences.

(8) 2 detector inputs minimum.

c. All interval timing shall be operator settable from the front panel of the unit. A conflict monitor shall be provided, either internal to the timer unit or shelf mounted. The controller cabinet shall be furnished with the number of load switches required to provide the sequence shown in the plans, but shall be capable of expansion to 24 signal circuits by the insertion of additional load switches.

d. Type 170 traffic signal controllers shall comply with FHWA Publication IP-78-16 with the following exceptions:

(1) Type 170 controllers shall be furnished with a model 412 system memory module complete with 4, 256-EPROM chips.

(2) All cabinets shall be furnished with a 3-lead 300-500 VDC gas discharge tube directly across the incoming power service, an EMI/RFI line filter before the main circuit breaker, and two 130 VRMS MOV having a transient energy dissipation of a minimum of 50 j connected to the load side of the line filter.

(3) Model 332, 330, and 336 cabinets shall be furnished with flash programming plugs for all 8 vehicle phases.

e. NEMA vehicle actuated controllers shall comply with NEMA Standards Publication TS-1 with the following exceptions: Controllers shall be furnished in 4-phase and 8-phase chassis only. If the controller is phase modular, the unit shall be furnished with a full complement of phase modules. Conflict monitors for 4-phase controllers shall be 6 channel. Monitors for 8-phase controllers shall be 12 channel. Cabinets shall be wired for the maximum number of phases plus 2 overlap phases, but shall be furnished with only those load switches required to provide the sequence shown in the plans.

f. The controller and all auxiliary equipment shall be housed in a weatherproof cabinet. The cabinet shall be of sufficient size to encase all control equipment and shall conform to the plans and the following requirements:

(1) The cabinet size shall be as stated in the plans. The manufacturer shall insure that not more than 60 percent of the internal cabinet volume is occupied by the required traffic control equipment.

(2) The cabinet shall be fabricated of high-grade aluminum alloy, sheet aluminum alloy, or rust-resistant copper bearing sheet steel.

(3) Cabinets shall be primed and finished with 2 coats of resin base paint. The finishing coats of paint shall be aluminum or silver in color unless otherwise specified. Brushed aluminum cabinets need not be painted.

(4) The cabinet shall contain a minimum of 2 metal shelves securely fastened to the side walls. The height and position of the shelves shall be easily changed or removed and replaced.

(5) The cabinet shall employ a roof design that extends over the main door.

(6) The main door of the cabinet shall substantially cover the full area of the front of the cabinet. This door shall be right hand hinged and allow complete access to the cabinet interior. A weatherproof and dustproof seal shall be provided between the door and cabinet using neoprene sponge or other approved gasket material.

(7) A door stop shall be provided for base mounted cabinets which securely holds the door at open positions of 90 and 135 degrees.

(8) The door hinge pins shall be made of stainless steel.

(9) A hinged auxiliary door of weatherproof design shall be provided on the front of the main door and shall be secured with a standard police lock furnished with 2 keys. The door shall house the switches described in the electrical design portion of this cabinet specification.

(10) All cabinets shall be secured using a Corbin No. 2 lock, or approved equal, and shall be provided with 2 keys.

(11) Pad mounted cabinets shall be provided with a 3-point door latch mechanism with a handle in addition to the Corbin No. 2 lock, or approved equal. This handle shall be designed to accept a padlock.

g. (1) A thermostatically controlled, ducted fan unit with a minimum rating of 2.83 m^3/min. in free air shall be installed in the cabinet to provide forced air ventilation through the cabinet. The fan unit shall be mounted to the inside top of the cabinet and shall be easily removed and replaced without having to dismantle any part of the cabinet or exhaust duct system.

(2) The fan shall intake air through filtered vents located near the bottom of the cabinet or cabinet door and exhaust it through a screened duct located near the top of the cabinet. Fiberglass type dry filters shall be used to cover the cabinet's air intakes. These filters shall be easily removed and replaced and be of standard dimensions commercially available.

h. A heavy-duty clear plastic envelope, securely attached to the inside wall of the cabinet or cabinet door, shall be provided for stowing the cabinet electrical prints. Minimum dimensions shall be 175 mm wide x 11 mm deep.

i. The cabinets shall be furnished with all of the hardware necessary for assembly and installation. The hardware shall include anchor bolts, anchor bolt template, pole mounting attachments, and all nuts, bolts, and washers necessary to assemble and install the cabinet as specified in the plans.

j. (1) The controller and all auxiliary equipment housed within the cabinet shall be designed to operate from 117 VAC 60 Hertz, single-phase, alternating current supply. Distribution of the 117 VAC throughout the cabinet shall not occur until the AC power has first passed through the power protection devices specified herein.

(2) The power protection devices shall include the main AC power circuit breakers, radio interference suppressors, and lightning and surge protectors. These devices shall be in addition to any protection devices furnished with the controller and auxiliary equipment housed within the cabinet. The protection devices shall be mounted to a panel that is securely fastened to an interior wall of the cabinet.

(3) The AC power field service shall be connected directly to a circuit breaker. This circuit breaker shall be a single pole, nonadjustable, magnetic breaker rated for 117 VAC operation with a minimum rating of 50 amperes. It shall be equipped with a solderless connector suitable for terminating 4.67 mm in diameter AWG wire. The circuit breaker shall be capable of manual operation and shall be clearly marked to indicate the "ON" and "OFF" positions.

(4) Radio interference suppressor(s) (RIS), adequate in number to handle the power requirements for the cabinet, shall be wired in series with and after the main AC power circuit breaker. The RIS shall be designed to minimize interference in all broadcast, transmission, and aircraft frequency bands.

k. As a minimum requirement, the lightning and voltage surge protectors shall be a combination of gas-type thyrectors rated for 350 volts operation and metal oxide varistors rated for 150 volts. The combination shall be wired in advance of the main circuit breaker and shall provide a direct path to ground. Additional protection shall be provided on all loop detector input terminals.

l. (1) All cabinet wiring shall be neatly trained throughout the cabinet and attached to the interior panels using non-conductive clamps or tie-wraps. Bundles of cables shall be laced or tied every 100 mm or enclosed in a sheathing material. The cabinet wiring shall not interfere with the entrance, training, or connection of the incoming or outgoing field conductors.

(2) Except where terminated by direct soldering, all wires shall be provided with terminal lugs for attachment to terminal blocks using screws. All wires shall be identified and labeled in accordance with the cabinet wiring prints.

(3) All wire insulation shall have a minimum rating of 600 volts.

m. The outgoing signal indication conductors shall be of the same polarity as the line (+) side of the AC field service to the cabinet. The incoming signal indication conductors shall be common and of the same polarity as the neutral (-) side of the AC field service. The neutral (-) side of the AC field shall be connected to the cabinet in an approved manner, usually to the copper ground bus. The cabinet shall, in turn, be connected to an earth ground through a ground rod.

n. The flashing operating switch shall control the power and flash transfer relays. It shall be labeled "AUTO-FLASH". In the "AUTO" position, normal controller operation prevails. When placed in the "FLASH" position, AC power is transferred from the load switches to the solid state flasher which, in turn, flashes the signal indications as specified. The vehicle detectors shall remain operational, but the AC power to the controller is interrupted.

o. The signal indication switch shall control AC power for the signal indications and shall not affect normal controller cycling. This switch shall be either a multipole toggle switch bussed together to obtain the required load rating or a circuit breaker. The minimum rating for the switch shall be 30 amperes and shall be labeled "SIGNALS-ON-OFF".

p. On the inside of the main door and accessible only when the main door is open shall be mounted a maintenance panel containing the test switches defined herein:

(1) The controller test switch shall allow the controller to be turned on for test purposes when the "AUTO-FLASH" switch on the Police Panel has been placed in the "FLASH" position. The switch shall be labeled "CONTROLLER", "TEST", "NORMAL".

(2) Detector test switches shall be used to manually place calls into the controller during actuated operation. These switches, one for each vehicle and pedestrian phase, shall be in parallel with the vehicle detector relay closure and pedestrian pushbutton circuits.

(3) A 3-wire ground fault type receptacle shall be provided and be easily accessible. This receptacle and the incandescent lamp shall be separately fused from and wired in advance of the main AC power circuit breaker.

(4) This assembly shall contain electromechanical relays used to transfer AC power and operation from the controller and load switches to the solid state flasher. This transfer relay assembly shall be controlled by either the "AUTO-FLASH" mode switch located on the Police Panel or the conflict monitor. The flasher shall remain operational with the controller removed from the cabinet.

(5) The cabinet shall be wired to flash amber for the main street and red for the cross streets. The red-yellow-flash indications shall be easily changed.

(6) The plug-in transfer relays shall be rated at a minimum of 20 amps per pole and shall be enclosed in a transparent case for protection against dust and for visual observance of operation.

q. The cabinet shall be furnished with an incandescent lamp mounted near the top of the cabinet interior. This lamp shall be controlled by either a manual switch mounted on the maintenance panel or by the main door using a pushbutton, refrigerator-type switch.

r. The cabinet fan (solid state controller only) shall be separately fused and wired after the main AC power circuit breaker.

s. (1) Molded composition barrier type terminal blocks shall be used for termination of the incoming and outgoing signals within the cabinet assembly. Each terminal block shall be one-piece construction with a minimum of 12 terminals. Each terminal shall have a threaded contact plate with a binderhead screw. The terminal blocks shall have minimum rating of 600 volts.

(2) All terminals shall be identified and labeled in accordance with the cabinet wiring diagram.

(3) The terminal block facilities shall be arranged in function groupings and mounted to either panels or brackets fastened to the interior walls of the cabinet. Each terminal block shall be retained using either machine or self-tapping screws and shall be easily removed and replaced.

t. Outgoing signal conductor terminals shall be provided for the vehicle and pedestrian signal circuits for each phase. The terminal blocks shall be of the barrier type using 4.7 mm in diameter or larger binderhead screws. These terminal blocks shall be located near the bottom of the cabinet, a minimum of 150 mm above the bottom surface for base mounted cabinets and 50 mm for pole mounted cabinets. A minimum number of 2 additional terminal blocks shall be provided for future expanded operation.

u. Controller input/output circuit terminals shall be provided and connected for all of the controller input and output circuits including those circuits which are not to be used on the project. The terminal blocks shall utilize 4.7 mm in diameter or larger binderhead screws.

v. (1) A special panel shall be provided with terminal blocks for terminating all circuitry associated with vehicle detectors and pedestrian pushbuttons. These circuits shall be wired to their respective termination points within the cabinet and shall be operational. The terminal blocks shall use binderhead screws.

(2) Terminals shall be provided for each vehicle detector including AC power, AC neutral, relay common, relay closure, and the loops or probes from the field. Solid state lightning protection devices shall be provided for each loop input from the field. A minimum number of 2 additional terminal blocks shall be provided for future expanded detection.

(3) Terminals shall be provided for each pedestrian pushbutton circuit from the field.

w. Unfused terminals shall be provided for the neutral side of the AC field service and all common conductors within the cabinet assembly. This terminal strip shall be made of copper and use 4.7 mm in diameter or larger screws. The ground bus shall be located on the panel with the main AC power circuit breaker and provide a minimum of 18 terminals.

x. The cabinet shall be wired for the maximum operation of the control unit including overlap and pedestrian phases. It shall only be necessary to add plug-in cabinet accessories (i.e., load switches, flash transfer relays, etc.) to obtain future operation.

y. All load switches shall conform to the triple-signal solid state type load switch as specified in the NEMA Standard Publication No. TS-1. Dual-signal type load switches shall not be allowed.

24. Vehicle Detector Amplifier:

a. Integrated circuits and/or descrete semiconductor devices and resistors, capacitors, transformers, etc. shall be used throughout the detector amplifier instead of vacuum or gaseous tubes and electromechanical devices except for the indicator light(s) and detector amplifier output replay. Logic design shall be such as to insure maximum noise immunity.

b. All solid state components shall be amply derated with respect to heat dissipating capacity and rated voltage. Shortening of component life or shift in values shall not occur at maximum operating temperature and voltage. The design life under continuous duty operation shall not be less than 5 years.

c. (1) All solid state components shall be individually replaceable and shall be readily available from any industrial electronics supply house.

(2) The solid state components used in the design of the amplifier shall be mounted on printed circuit (PC) boards. The PC boards shall be fabricated from glass-epoxy laminate, NEMA grade G-10, with a minimum thickness of 1.5 mm. Intercomponent circuit traces shall be copper track, with a minimum mass of 605 g/m^2 and shall be of adequate cross-sectional area to carry the designed current. All holes in the PC board utilizing intercomponent circuit traces on 2 sides shall be plated through.

(3) All solid state components mounted and soldered to the PC board shall be easily removed and replaced without causing damage to the board or tracks.

(4) All solid state components contained on the PC board shall either have their circuit reference symbol clearly marked on the board or be easily identifiable by referring to pictorial assembly drawings.

(5) The vehicle detector amplifier defined in these *Specifications* shall maintain normal operation over all combinations of temperature and voltage ranging from 105 to 136 VAC and -34°C to +74°C ambient. The use of auxiliary heating and cooling devices which would reduce the operational temperature range in order to achieve satisfactory performance shall not be allowed.

(6) The amplifier shall have a light for each detection channel to indicate vehicle detection. All indicator lights shall have a minimum design life of 20,000 hours at rated voltage and shall be easily replaceable. All indicator lights, when illuminated, shall be visible in bright sunlight.

(7) All tuning and/or sensitivity adjustment shall be made from the front of the enclosure without the use of tools. The connector and the tuning and detection indicator(s) shall be mounted on the front of the enclosure.

(8) Service personnel shall have complete access to any part of the detector amplifier assembly for test and/or maintenance without affecting the warranty.

25. Loop Vehicle Detector Amplifiers:

a. Loop vehicle detector amplifiers shall be of Type 170 or NEMA shelf mounted type as required by the controller with which it will be used.

b. Type 170 loop amplifiers shall be model 222 and shall comply in all respects with FHWA publication IP-78-16.

c. NEMA Type loop amplifiers shall conform to the following requirements:

(1) Sensitivity shall be selective for a minimum of 3 positions in regular increments.

(2) All electrical connections and adjustments shall be made on the front panel without the use of special tools. Connection shall be made using an MS 3102 A18-1P connector.

(3) No burn-in or warm up time shall be required before the detector amplifier is fully operational.

(4) The loop detector amplifier shall operate properly despite resistive leakage or total grounding of the loop.

(5) Loop detector amplifiers with more than one detection channel shall have lightning protection on each channel separately with complete immunity to crosstalk between channels. Each detection channel shall be electrically connected through a separate MS 3102 A18-1P connector. Mode of operation and sensitivity adjustments shall be independent between channels. Multiple channel detection amplifiers shall also comply with all other conditions of these *Specifications*.

(6) The loop detector amplifier shall provide a minimum of 2 modes of operation. The pulse or presence mode shall be switch selective on the front panel.

(7) The loop detector amplifier shall produce an output pulse of a 100 milliseconds duration for each vehicle entering the detection zone. Any vehicle stopped on the loop for 2 seconds or more shall be automatically tuned into the resonant circuit so that any unused portion of the loop may detect passing vehicles.

(8) The unit shall provide a detection output for as long as the vehicle remains in the detection area or for at least 10 minutes after which it shall be incorporated in the background inductance so that any unused portion of the loop may detect passing vehicles.

(9) The loop detection amplifier shall employ a digital self-tuning system which is activated automatically with each application of power. It shall self-tune during the process of connecting the mating connector and immediately following any power failure. The unit shall automatically return to the correct tuning level after a vehicle which has been incorporated into the background inductance moves away. Automatic and continuous fine tuning shall be featured to correct for the environmental drift of the loop impedance.

(10) The output relay shall be a failsafe relay (SPDT) with a contact rating of at least one ampere at 117 VAC. If specifically stated, the output shall be failsafe solid state switch, zener protected for 40VDC at 0.25 amp.

(11) Each vehicle detector amplifier shall be enclosed in a sheet aluminum case with a durable protective finish. This enclosure shall be easily removed allowing convenient access to the solid state circuitry. All electrical connections to the device shall be made using type MS multipin threaded shell connectors. The mating MS plug receptacle shall be attached to one end of a connecting cable at least 750 mm long.

26. Magnetic Vehicle Detector Amplifier, Type 170

a. Magnetic vehicle detector amplifiers shall be either a Type 170 card rack mounted or NEMA shelf mounted as required by the type of controller with which they are to be used.

b. Type 170 magnetic detector amplifiers shall be model 232 and shall comply with FHWA publication IP-78-16.

c. Magnetic amplifiers for use with NEMA controllers shall conform to the following requirements:

(1) Detection is achieved by monitoring the earth's magnetic field. The earth's magnetic field is momentarily disturbed where a vehicle passes within close proximity of the detector. This disturbance will induce a signal voltage in the coil which is applied to the amplifier input.

(2) The unit shall be designed to provide amplification of the signals produced by all vehicles ranging in size from a motorcycle to a tractor-trailer traveling at speeds of 8 km/h or greater over the magnetic detector.

(3) The unit shall be designed to operate satisfactorily with the magnetic detector supplied.

(4) The amplifier shall be provided with an indicator light that is visible from the front of the case and will light momentarily to indicate an actuation. It shall be provided with a knob on the front of the case for adjusting the degree of amplification of the electrical energy from the detector. On the front of the unit adjacent to the adjustment dial and MS connector, there shall be mounted 2 test jacks labeled J101 and J102 for the purpose of checking the proper adjustment of the sensitivity knob.

(5) The registration of overlapping impulses from 2 detector relay units shall be ensured by the use of normally open and normally closed contacts provided on the output relay. Any contact that opens or closes in response to vehicle actuations shall be capable of making, breaking, and carrying 3 amperes at 120 volts AC.

(6) The amplifier circuits shall be designed using semiconductor devices and shall operate with maximum stability and reliability under conditions of line voltage fluctuation up to 5 percent. Circuits employing printed circuits shall be of the highest quality with extra-heavy (605 g/m^2 or better) copper.

(7) The amplifier shall be designed for operation at 120 volts, 60 cycle, single phase. Maximum power consumption shall not exceed 5 watts and shall be suitably enclosed in a durable, protective case. It shall be supplied for plug connection.

(8) All circuits shall be designed to provide stable operation within an ambient temperature range of -34 to +82°C.

(9) (i) The unit shall be housed in a durably finished fabricated sheet aluminum case.

(ii) Removal of the unit from its case shall require the use of simple tools. The removal of 2 screws shall allow access to the printed circuit panel and components.

(iii) Electrical connections of both the incoming and outgoing circuits shall be made by means of an 8 terminal MS type plug. The unit shall be replaceable with a similar unit without the necessity of disconnecting or reconnecting individual wires leading therefrom. The type MS plug shall be a protected male plug and shall be rigidly fixed to the front of the unit.

(iv) The mating MS plug receptacle shall be attached to one end of the connecting cable and be at least 600 mm long. The other end of the connecting cable shall have tagged leads, each of which shall be fitted with a spade type lug for easy attachment to the terminal blocks.

27. Vehicle Detector-Magnetic, Type TD-3:

a. This specification defines the minimum detailed requirements applicable to the magnetic vehicle detector. The detector will operate on the principal that all vehicles create their own magnetic fields as they move through the earth's magnetic field. This causes an induced voltage in the coil of the detector. The voltage is amplified by a device and actuates a relay to operate the controller.

b. Operational Features:

(1) The magnetic detector shall be designed for installation in or near the roadway, capable of being actuated by the magnetic or electrical disturbance caused by the passage of a vehicle.

(2) The operation of the detector shall not be affected by parked cars or other stationary metallic objects in or upon the roadway.

(3) The detector, when used with the proper amplifying device, shall be capable of actuation by any vehicle passing the detector at the distance and speeds indicated below:

(i) At a speed of 20 to 130 km/h--within 4.6 m of the detector.

(ii) At a speed of 12 to 130 km/h--within 3 m of the detector.

(iii) At a speed of 5 to 130 km/h--within 1.5 m of the detector.

c. Mechanical Requirements:

(1) The detector shall have sufficient mechanical strength to withstand normal handling and the transmitted shock of vehicular loads when installed in accordance with the manufacturer's instructions.

(2) The detector shall have a moisture-proof housing designed for underground operation. The detector's operation shall not be affected by temperature, humidity, or soil conditions.

(3) The detector shall be provided with means for making a waterproof connection to the cable or closed conduit system and shall be provided with insulated leads at least 15 m long.

(4) The detector shall be designed for use with one or more types of devices for amplifying, rectifying, or otherwise intensifying the electrical energy produced by the detector.

28. Pedestrian Pushbuttons:

a. Pedestrian pushbuttons shall be of the type and style specifically intended for the application shown in the plans. They shall be housed in a durable casting and be weathertight. The button and mechanism shall be of sufficient size and rugged design to withstand some abuse and discourage vandalism. The internal switching device shall be closed by physical contact with the button.

b. Signs shall be provided for mounting directly above the pedestrian pushbuttons indicating which pedestrian signal is associated with that particular button. These signs shall be of the size, type, and style specifically intended for that purpose and shall be provided by the manufacturer of the pedestrian pushbuttons. Each sign shall include an arrow to indicate the direction of the crossing to which the button applies.

29. Hardware:

a. All ferrous bolts, nuts, clamps, miscellaneous hardware, and fittings shall be galvanized according to ASTM A 153.

b. All other material or fittings necessary to complete the work shall be approved by the Engineer.

c. Saw cuts and holes made in the roadway for installation of vehicle detectors shall be sealed with a sealant that is on the NDR Approved Products List.

d. Chemical and physical properties of sealants are similar, but the potting and hardening time varies with temperature and composition of the particular mix. The Contractor shall assume responsibility for the type of sealant used on a particular project under the prevailing environmental conditions.

e. Approval of other sealants will be determined from the manufacturer's technical information and actual samples taken and tested by the NDR before installation.

30. Traffic Signal Poles:

a. This specification shall be intended as the minimum requirements for furnishing mast arm and span wire signal poles of various sizes with and without lighting. Each signal pole supplied for installation shall conform to the plans and these *Specifications*.

b. (1) Each pole shaft, luminaire extension, luminaire mast arm, and signal mast arm shall be formed of proper steel to a tapered shaft and shall have only one longitudinal automatic electric weld. Each steel shaft shall be treated after forming and welding to flatten the weld.

(2) Each pole shaft, luminaire extension, signal arm, and luminaire arm shall be furnished with all miscellaneous hardware necessary to complete the signal pole assembly. Miscellaneous hardware shall include pole caps, handhole covers, anchor bolt covers, anchor bolts, and all bolts, nuts, and washers necessary to complete the signal pole assembly and installation.

(3) A one-piece steel anchor base of adequate strength, shape, and size shall be secured to the lower end of the shaft by 2 continuous electric arc welds. The base shall telescope the shaft. One weld shall be on the inside of the base at the end of the shaft, while the other weld shall be on the outside at the top of the base.

(4) A grounding nut for accommodating a 4.67 mm diameter bare copper wire shall be provided on the inside of the shaft 200 mm above the bottom weld joining the shaft to the anchor base. The grounding nut shall be mounted directly opposite the handhole opening and shall not be allowed on the handhole frame.

(5) When specifically required by the plans, a transformer base shall be provided. In such case, the handhole in the pole shaft is not required and the grounding nut shall be located in the transformer base.

c. Anchor Bolts:

(1) Anchor bolts shall be supplied by the pole manufacturer. The manufacturer shall certify that the bolts are of adequate strength to resist the loading required in these *Specifications* and the Nebraska Signal Pole Standard.

(2) All anchor "J" bolts shall comply with Standard Plan 912 and be M42 diameter by 1.37 m long with a 150 mm hook. Each anchor bolt shall be threaded and galvanized to a length that will insure that all parts of the bolt exposed after installation are galvanized. Threads shall be full and sound. Each anchor bolt shall be furnished with 2 hexagon nuts and 2 flat washers.

d. A removable pole top shall be furnished with pole shafts and luminaire extensions complete with a positioning cap screw.

e. A plate shall be welded interior to the top of each pole shaft for mounting a luminaire extension. The bolt circle shall be 140 mm diameter. The 4 holes shall be drilled and tapped to accommodate 25 mm (M24) bolts. A 75 mm diameter hole shall be provided in the middle of the plate for passage of electrical cable.

f. Signal mast arm and luminaire arms shall be furnished with a clamp-on mounting device suitable for attaching the arm to its respective shaft at the height specified. The clamp-on mount shall be structurally sound and neat in appearance. The signal arm mount shall provide a minimum 2 percent rise and a maximum 4 percent rise for each loaded signal arm or shall be adjustable in the field.

g. Handholes:

(1) All handholes shall be reinforced to maintain full strength of the steel shaft. Handholes shall have a minimum opening of 100 mm x 150 mm. Handhole covers of a weatherproof design shall be supplied by the pole manufacturer.

(2) Mounting of the grounding nut on the handhole frame shall not be allowed.

(3) The bottom of the handhole opening shall be at least 75 mm above the top of the base.

h. Signal arms, luminaire arms, luminaire extensions, and pole shafts shall be supplied with 25 mm I.D. rubber grommets as shown on the pole standard plan. Signal arms shall also be supplied with 25 mm I.D. rubber grommets for the number of signals specified in the loading chart in the plans. Cable inlet holes shall be drilled in the field by the Contractor.

j. Loads: (1) Each pole shaft, luminaire extension, luminaire arm, and signal arm shall be galvanized to comply with ASTM A 123.

(2) All miscellaneous hardware shall be galvanized in accordance with ASTM A 153.

j. (1) The pole shall be designed to support the signal load shown in the plans plus one additional signal head per span and shall withstand wind velocities up to 160 km/h. The design mass of the signal head shall be 34 kg with a surface area of 0.65 m^2.

(2) The poles shall be designed to support the required signal and luminaire load, mast arms with 15 kg of ice per linear meter, and signal and lighting cables while withstanding winds with velocities up to 160 km/h.

(3) The pole shaft and signal mast arm shall be designed to support either a 2 or 3 signal head load as indicated in the plans with 3.65 m of separation.

k. The manufacturer shall state the necessary amount of pole-rake necessary for the pole to set plumb under the required signal and lighting load in the plans.

l. A certificate of compliance verifying the adequacy of the signal poles and their conformity to these *Specifications* shall be submitted to the NDR Traffic Engineer. The certificate shall state that the pole and anchor bolts shall not fail under the loading requirements of these *Specifications*.

31. Pedestal Traffic Signal Pole:

a. Pedestal traffic signal poles shall consist of a threaded aluminum or steel shaft and an appropriate threaded base, together with anchor bolts to provide the mounting height and accept the traffic signal hardware as shown in the plans.

b. The pedestal pole assembly shall have the characteristic of yielding under impact when struck by a motor vehicle to cause a minimum of decelerative effect upon the vehicle so as to reduce vehicle damage and personal injury potential. This yielding characteristic shall be provided by a breakaway base constructed of cast aluminum which shall be of such design that adequate static strength is maintained to support the pole, traffic signal, and mounting hardware along with ice and wind loadings.

c. The base shall be approximately 450 mm high and not more than 430 mm in diameter at the bottom.

d. The base shall have an opening on the side of not less than 25,800 mm^2 which is covered by a door secured with a stainless steel screw.

e. There shall be a grounding nut located inside the base directly across from the opening and sized to accommodate a 4.67 mm diameter bare copper conductor.

f. If the Contractor elects to furnish and install aluminum pedestal poles, they shall be fabricated from spun seamless tubing conforming to ASTM B 210M, Aluminum Alloy 6063-T6.

g. If the Contractor elects to furnish and install steel pedestal poles, they shall be fabricated in accordance with the applicable requirements of Paragraphs 5. and 6. of this Subsection.

32. Wood Poles:

a. Poles shall be Southern Yellow Pine or Douglas Fir of the Coast Region. Poles shall conform to American Standard 05.1 and shall be the length and class shown in the plans.

b. The preservative treatment shall be by the Empty-cell (Rueping) or Full-cell (Bethell) Process, whichever applies, and shall conform to the requirements specified in Standard C4 of the American Wood-Preservers' Association, with the exception that creosote is excluded.

c. Southern Yellow Pine poles (up to 13.7 m) shall be treated with not less than 6.0 kg of pentachlorophenol or 9.6 kg of ammoniacal copper arsenate (ACA) or chromated copper arsenate (CCA) per cubic meter of timber.

d. Southern Yellow Pine poles (13.7 m and larger) shall be treated with not less than 7.2 g of pentachlorophenol or 9.6 kg of ammoniacal copper arsenate (ACA), or chromated copper arsenate (CCA) per cubic meter of timber.

e. Douglas Fir poles shall be treated with not less than 9.6 kg of pentachlorophenol, ammoniacal copper arsenate (ACA), or chromated copper arsenate (CCA) per cubic meter of timber.

f. The pentachlorophenol, ammoniacal copper arsenate, and chromated copper arsenate shall meet the requirements of Section 1076.

g. Poles to be treated with ammoniacal copper arsenate or chromated copper arsenate shall be dried to the fiber saturation point required to put the timber into satisfactory condition to accept the preservative and attain the required preservative retention and penetration. After treatment, the poles shall be redried and have a moisture content of not more than 30 percent at the time of shipment to the job site.

h. Each pole shall be marked in accordance with requirements of American Standard 05.1. The marking on the face of the pole shall be located approximately 3 m above the butt of the pole.

i. Poles shall be carefully selected for straightness.

j. Poles in line shall not have sweeps and short crooks exceeding 50 percent of the maximum sweeps and short crooks allowed in the American Standard and shall present a neat appearance after installation.

k. The number of poles containing the maximum sweeps and short crooks allowed in the American Standard shall be kept to a minimum. These poles shall be installed in locations where they will not detract from the general appearance of the line of poles.

l. Poles that are to be given a full-length preservation treatment shall be roofed, gained, and bored before treatment.

m. Gains shall be cut on the face (concave side) or side of greatest curvature in poles having reverse or double sweep between the ground line and the top of the pole, and the gained surfaces shall be in approximately parallel planes.

n. Poles stored for any reason more than 2 weeks shall be stacked on creosoted or decay-resisting skids of such dimensions and so arranged as to support the poles without producing noticeable distortion in any of them.

o. Poles shall be stored to allow free circulation of air, and the bottom poles of a pile shall be at least 300 mm above the ground level or any vegetation.

p. No decayed or decaying wood shall be allowed to remain underneath stored poles.

q. Treated poles shall not be dragged along the ground.

r. Pole tongs, cant hooks, and other pointed tools capable of producing indentations more than 25 mm in depth shall not be used in handling the poles.

s. No tools shall be applied to the groundline section of any pole. The groundline section is that portion between 300 mm above and 600 mm below the groundline.

t. The basis of acceptance of wood poles shall be as prescribed in Section 1075.

33. Anchors for Guy Wires:

a. Anchors for guy wires shall have a 200 mm minimum diameter and shall be a type appropriate for the soil conditions.

b. Anchor rods shall be 15.8 mm galvanized steel rods 2.4 m in length with a thimble eye end.

c. Guy guards shall be half-round galvanized metal guards, 2.4 m in length.

d. Bonding clamps shall be galvanized clamps providing a continuous column of metal wedged solidly between the anchor rod and the guy strand. Bonding clamp expansion shall be accomplished by tightening a set screw.

34. Span and Tie Wire:

Span wire and tie wire shall conform to the requirements of Section 1062.

1073.03 -- Acceptance Requirements

All items described in this Section are accepted as prescribed or as indicated in the NDR *Materials Sampling Guide*.