## Section 2525. Traffic Signalization

### 2525.01 DESCRIPTION.

Furnish all work, apparatus, and materials to construct, install, and place in operation, a complete traffic signal system as shown in the contract documents. Furnish and install all components of the system not furnished by the utility company serving the traffic signal system, including all incidental items appurtenant to the operation of the system.

### 2525.02 MATERIALS.

Furnish materials of new stock unless the contract provides for the relocation or the use of fixtures furnished by others.

**A. Power Cable.**
Comply with Article 4185.12. UL listed for type "USE".

**B. Signal Cable.**
Meet the requirements of IMSA Nos. 19-1 or 20-1.

**C. Loop Detector Wire.**
Single conductor meeting standard requirements for THHN. Meet the requirements of IMSA No. 51-5.

**D. Detector Lead-In Cable.**
Meet the requirements of the IMSA No. 50-2.

**E. Tracer Wire.**

1. Single conductor, stranded copper, Type THHN, with UL approval and orange colored jacket.

2. Splice tracer wires in the handholes, cabinet, and pole bases to form a continuous network.

**F. Communications Cable (Conductive).**
Meet the requirements of the IMSA No. 39-2 or 40-2.

**G. Bare Copper Ground Wire.**
Meet the requirements of Article 4185.12.

**H. Conduit.**

1. **General.**
Meet the requirements of Article 2523.03, N and Article 4185.10.

2. **Rigid Steel Conduit.**
Use conduit fittings meeting the requirements of ANSI C80.4.

3. **Polyvinyl Chloride Conduit.**
Use rigid PVC conduit meeting the requirements of NEMA TC-2, Type 2, and applicable UL Standards.

4. **Innerduct.**
For innerduct conduit (IDC), use Schedule 40, high density polyethylene. Conduit shall provide nominal conduit size as indicated in the contract documents, be orange in color, and longitudinally ribbed on the inside wall. Conduit shall be purchased in continuous reel lengths to minimize splicing.

## 2525.03 CONSTRUCTION.

### A. General.

1. Furnish equipment and materials of new stock unless the contract provides for the relocation or the use of fixtures furnished by others.

2. Submit to the Engineer, for review, a list of equipment and materials to be furnished before they are ordered. Replace, at no additional cost to the Contracting Authority, any part that fails in any manner by reason of defective materials within a period of 1 year from the date that the equipment was placed in operation and accepted. Provide the standard industry warranties for all equipment at the date of final acceptance of the work by the Engineer.

3. Shop drawings will be required for the poles and mastarms. Submit shop drawings according to Article 1105.03.

4. Prior to acceptance of the work, the Contractor will be required to furnish the Engineer with:
   - Five copies of the manufacturer's instructions for maintenance and operation of all signal equipment,
   - Wiring diagrams of the installation or system, and
   - A parts list sufficient for the ordering of parts.

### B. Handholes.

1. Build handholes in place or furnish precast units. When forms are used, use forms that are set level and are of sufficient thickness to prevent warping or other deflections from the specified pattern. Provide a means for holding them rigidly in place while the concrete is being placed.

2. Use concrete meeting the requirements of Section 2403.

3. Extend the ends of all conduit leading into the handhole approximately 2 inches (50 mm) beyond the inside wall.

4. Construct a drain in the bottom of the handhole. Furnish frames and covers for handholes made of cast iron.

5. Furnish handhole covers with the words "TRAFFIC SIGNAL" cast on the top of the cover. Set them flush with the sidewalk or pavement surface.

6. When installed in an earth shoulder away from the pavement edge, install so the top surface of the handhole is approximately 1 inch (25 mm) above the surface of the ground. When constructed in unpaved driveways, install so the top surface of the handhole is approximately level with the surface of the driveway.

**C. Conduit System.**

Apply Article 2525.02, H.

**1. Installation.**

**a.** Accomplish change in direction of ducts by:

- Bending the conduit uniformly to a radius which will fit the location (minimum radius 6 times the internal diameter of the conduit), or
- The use of standard bends or elbows.

**b.** When it is necessary to cut and thread steel conduit, no exposed threads will be permitted.

**c.** Ensure all ducts and fittings are free from burrs and rough edges.

**d.** Use standard manufactured elbows, nipples, tees, reducers, bends, couplings, unions, and so forth of the same materials and treatment as the straight duct throughout the duct system. Tightly connect all fittings to the duct. Provide a bushing to all duct ends to protect the cable from abrasion, except for open ends of conduit being placed for future use. Cap or plug open ends intended for future use.

**e.** When the contract documents require that ducts be placed without disturbing the existing pavement, the term "pushed" is used. Place pushed conduit by jacking, pushing, boring, or any other means necessary to place the ducts without cutting or removing pavement.

**f.** Slope all ducts to drain. Furnish crushed stone drainage sumps at all handhole locations.

**2. Excavation.**

**a.** Excavate trenches to the depth necessary to provide 18 inches (0.5 m) of cover over the ducts. Remove all cinders, broken concrete, or other hard or abrasive materials. Do not use these materials as backfill materials. Ensure the trench is free of these materials before the conduit is placed.

**b.** Do not place ducts prior to the Engineer’s inspection of the trench. Place backfill material in all trenches as soon as possible after duct installation. Place backfill material in the trench in layers not to exceed 6 inches (150 mm) deep. Thoroughly compact each layer before placing the next layer.

**c.** Whenever excavation is made across parkways, driveways, or sodded areas, replace or restore the sod, topsoil, crushed stone, and gravel as nearly as possible in its original position. Leave the whole area involved in a neat and presentable condition.

**d.** Replace concrete sidewalks, pavements, base courses, and bituminous surfaces with new materials.

**D. Wire and Cable.**

Apply Articles 2525.02, A through G.

1. Install all cable runs so they are continuous from connections made in the handhole compartments of signal pole bases to the terminal compartment in the controller cabinet. Splicing will not be allowed. Install one signal cable from each signal head to the base of the pole. Use a 5-conductor cable in the poles for 2-section, 3-section, or 4-section signal heads. Use a 7-conductor cable for 5-section signal heads.

2. Install service cable runs so they are continuous from the service point to the terminal compartment on the controller cabinet. Connect loop detectors to the controller using a 14 AWG 2-conductor shielded cable. Install these cables to be continuous from the terminal compartment in the controller cabinet to a splice made with the detector leads in the first handhole or pole base junction box provided adjacent to the detector.

3. Pull cables through conduit by means of a cable grip designed to provide a firm hold upon the exterior covering of the cable or cables, with a minimum of dragging on the ground or pavement. Use reels mounted on jacks or other suitable devices. Use frame mounted pulleys or other suitable devices to pull the cable out of conduit into handholes. Use lubricants which are approved for cable lubrication to facilitate the pulling of cable. Provide slack for each cable by the use of a 4 foot (1.2 m) loop in each handhole.

**E. Controllers, Cabinets and Associated Equipment.**

**1. General Design Requirements.**

**a. Purpose.**

The purpose sets forth minimum design and operating requirements for controllers, cabinet and associated equipment. Furnish controllers, cabinets, and associated equipment complying with NEMA TS-1, except as modified by the contract documents.

**b. Cabinet.**

**1)** Furnish controller units and associated equipment that are completely housed in a cabinet of clean-cut design and appearance. The cabinet shall be constructed from 5052-H32 sheet aluminum alloy which has a nominal 0.12 inch (3 mm) thickness.

**2)** Furnish a hinged door that meets the following requirements:

- Permits complete access to the interior of the cabinet.
- When closed, fits the gasketing material making the cabinet weather resistant and dust tight.
- Includes a strong Corbin #2 lock and key, or approved equal.

**3)** Ensure the outside of the main controller door includes a small, hinged and gasketed door-in-door that:

- Does not allow entrance to the controller mechanism or to exposed electrical terminals,
- Provides access to a small switch panel and compartment which contains a signal shutdown switch, manual/stop time, and a flash control switch, and

- Is equipped with a strong lock utilizing keys of a different design from those provided for the main cabinet.

**c. Wiring.**

**1)** Furnish panels that have mounted on them at least the following short circuit protection devices and suitably identified field terminals:

**a)** Terminals for the conductors of the signal light cable. One for each signal circuit.

**b)** Terminals for common return conductors of the signal light cable. At least one for each three signal circuits for which the controller is equipped.

**c)** Terminal grounded to the cabinet or an equipment grounding conductor.

**2)** The grounded side of the power service is to be carried throughout the controller in a continuous circuit, but do not ground it to the controller cabinet.

**3)** Furnish controllers that withstand without failure a high energy transient (1000 volts, both positive and negative, applied three times for each polarity at a rate of once every two seconds from a 15 microfarad oil filled capacitor) applied to the incoming power supply line.

**d. Contacts.**

For all contacts, meet the following requirements:

- Fabricated from coin or fine silver or material of similar conductivity,
- Sufficient cross section to perform their normal functions with minimum pitting or burning under maximum current, and
- No fine adjustment and readjustment required for satisfactory and continuous operation.

**e. Mechanical Requirements.**

Meet the following requirements:

**1)** All mechanism, motors, operating coils, bearings, contacts, relays, flashers, and similar components sufficiently large, rugged, and accessible to ensure reliability and minimum maintenance.

**2)** All equipment neatly and systematically arranged and mounted to allow thorough inspection while the controller is operating normally, and to permit easy removal of components without interfering with other portions of the controller.

**3)** Components securely fastened in place, if necessary to prevent accidental contact with moving parts or electrical power and to permit the cabinet door to be opened and closed without interference or damage to the controller and wiring.

**4)** The opening and closing of the flashing circuit accomplished in such manner as to avoid undue pitting or burning or other damage of signal load switches at 10 amperes of tungsten lamp load at 120 volts, 60 hertz AC, for 50 million times.

**a)** Each equipped with additional terminals which are wired so that, by an interchange of jumpers, flashing operation may be arranged to display either flashing yellow or flashing red on each.

**b)** Cabinet constructed so that flashing operation can be obtained by operating the flash control switch even if the controller unit malfunctions or is removed from the cabinet.

**c)** Each cabinet equipped with adequate means to suppress or prevent radio interference from flashing of vehicular and pedestrian signal indications.

**f. Uninterrupted Timing.**

Ensure changes in operation of traffic control signal lights as described in Article 2525.03, E, 1, b, 2, and Article 2525.03, E, 1, e, do not interfere with the continued in-time operation of the cycle timer in each controller. A transfer from these special operations back to normal automatic operation is to immediately re-establish the normal cycle length and subsequently the in-time relation.

**2. Preemption Features.**

Furnish controllers equipped to provide special preemption sequences upon remote control from railroad track circuit, emergency vehicle preemption, mass transit equipment, or other similar device which may connect either through a master controller or directly to the interconnected controller.

**3. Actuated Signal Controllers.**

**a. Description.**

Furnish NEMA TS-1 or TS-2 controller units that:

- Are of completely solid state modular design,
- Incorporate digital timing, and
- Are capable of expanding to accommodate up to eight phases.

**b. Electrical Requirement.**

**1) Over-current Protection.**

Furnish controllers that contain a front-panel-mounted AC power input fuse of suitable size to provide adequate over-current protection.

**2) Automatic Reorientation.**

Furnish controllers that in the event of a power interruption are capable of automatic reorientation upon power resumption and require no manual initiation or switching.

**c. Constancy of Intervals: Minimum Requirements.**

Ensure the length of any interval or timing setting does not change by more than 100 milliseconds (±) so long as the voltage and frequency of the power supply and the ambient temperature inside the controller cabinet remain within the tolerances specified in these specifications.

**d. Interval Sequence.**

Ensure that at the end of the green interval of the terminating phase, if neither vehicle nor pedestrian memory indicates a need for the next traffic phase, the intervals which comprise that phase are omitted from the interval sequence. This does not preclude the use of recall causing the phase to be displayed even though no detector actuations have been received.

**e. Interval Setting and Functions.**

**1) Provision for Setting.**

Furnish controls that meet the following requirements:

- Calibrated in seconds and fractions of seconds, when applicable.
- Provide a clear visual indication of the value of each interval or function.
- Timing and function values capable of being set without the use of special tools or wiring changes.

**2) Location of Controls.**

Furnish controllers with the interval and function controls located on the front of the controller and properly designated as to the function each control performs.

**3) Interval and Function Indication.**

**a) Indication.**

Furnish controllers with indication provided and appropriately labeled on the controller to facilitate the determination of operation and termination of the intervals and functions contained therein. Indication shall include, but not necessarily be limited to, the following:

- Phase(s) next.
- Phase(s) in service.
- Status indicators.
- Initial interval.
- Vehicle interval.
- Yellow change interval.
- Maximum/gap termination.

**b) Call Indication.**

Furnish controllers on which indication is provided to display presence of vehicle call, including memory and detector actuations and presence of a pedestrian call when pedestrian timing functions are included.

**4) Vehicle Detector Non-Lock Memory Switch(es).**

Ensure a switch is provided for each actuated vehicle phase which, when placed in the nonlock position, causes the vehicle detector memory circuit for that phase to be disabled.

**f. Signal Circuits.**

**1) General.**

Furnish cabinets with load switches, external to the controller, for closing and opening signal light circuits.

**2) Closing and Opening of Circuits/Minimum Capacity.**

Ensure closing or opening of signal circuits is positive without objectionable dark intervals, flickering of lights or conflicting signal indications. Ensure each switch has a capacity of no less than 10 amperes of incandescent lamp load at 120 volts AC.

**3) NEMA Triple Signal Load Switch(es).**

Furnish external jack-mounted load switches according to Part 5, "Solid-State Load Switches", Section TS-5.01, NEMA Traffic Control Systems Standards.

**g. Conflict Monitor.**

Furnish a separate external signal monitoring device complying with Part 6, NEMA TS-1 that monitors the occurrence of conflicting

Green or Walk indications and causes the signals to go into flashing operation should such conflicts be sensed.

**1) Control of Flasher Mode.**

Meet the following requirements:

**a)** Operation of flash mode from police panel does not interrupt operation of controller and associated units.

**b)** An "auto-off-flash" mode switch is provided inside the cabinet.

**2) Flashing of Vehicular Signals.**

Meet the following requirements:

**a)** Flashing of vehicular signal indications is obtained from one or more flashers, each of which is a self-contained device designed to plug into a panel in the controller cabinet.

**b)** If the flashing is provided by two flashers, they are wired to assure that the flashing of all lenses on the same approach is simultaneous.

**3) Flashing of Pedestrian Signals (Pedestrian Clearance).**

When pedestrian interval timing functions are included, ensure means are provided to permit flashing of the DON'T WALK pedestrian signals during the pedestrian clearance interval.

**4) Solid State Flasher.**

Furnish solid state flashers that:

- Contain no contact points or moving parts, and
- Comply with Part 6, NEMA Traffic Control Systems Standards TS-1.

**h. Manual Control Enable.**

Ensure, when specified, manual commands:

- Place vehicle calls and pedestrian calls (when pedestrian timing is included in the controller's sequence of operation) on all phases and stop controller timing in all intervals except vehicle clearances, and
- Inhibit the operation of interval advance during vehicle clearances.

**i. Coordination.**

**1) Minimum Requirements.**

Furnish controllers with the means to permit its interconnection into a coordinated traffic signal system when coordinating devices are added. As a minimum, this should include the provision of Yield circuit or Hold circuit, accessible to interruption by command external to the controller.

**2) Coordination Requirements.**

Ensure controllers, in addition to the minimum coordination requirements specified above, contain the coordination features for the applicable configuration included in NEMA Traffic Control Systems Standard TS-1.

**j. Cooling/Heating Devices.**

No heating or cooling devices other than standard vent fan(s) are required for proper operation of the controller.

**k. Cabinet.**

**1) Size.**

Furnish cabinets of a size to adequately house the controller, all associated electrical devices and hardware, and other auxiliary equipment herein specified.

**2) Mounting.**

**a)** Ensure the cabinet is arranged and equipped for mounting as shown in the contract documents. Also ensure sufficient clamps, nuts, hardware, etc., as required for the specified mounting type, are furnished with each cabinet.

**b)** Seal all conduit openings in the controller cabinet with a sealing compound that meets the following requirements:

- Readily workable, soft plastic,
- Workable at temperatures as low as 30ºF (-1ºC), and
- Does not melt or run at temperatures as high as 300ºF (150ºC).

**c)** Install the controller cabinet on preplaced caulking material on the concrete base. After the cabinet is installed in place, also place caulking material around the base of the cabinet.

**3) Door Stop.**

Ensure the controller cabinet door is provided with a stop and catch arrangement to hold the door open at angles of both 90 degrees and 180 degrees, ±10 degrees.

**4) Mounting Shelves.**

Furnish cabinets containing strong mounting facilities to:

- Accommodate the mounting of the controller and all auxiliary equipment, and
- Permit the controller and/or auxiliary equipment to be withdrawn from the cabinet for inspection or maintenance without breaking any electrical connections or interrupting operation of the controller.

**5) Mounting Screws.**

Do not allow screws used for mounting shelves or other mounting purposes to protrude beyond the outside wall of the cabinet.

**6) Outlet and Lamp.**

Furnish and locate an electrical outlet with a Ground Fault Interrupter and lamp receptacle in an accessible place near the front of the cabinet.

**7) Plastic Envelope.**

Furnish a heavy-duty clear plastic envelope (minimum dimensions of 12 inches by 18 inches (300 mm by 450 mm)), securely attached to the inside wall of the cabinet or cabinet door, for stowing cabinet electrical prints, and so forth.

**8) Ventilation.**

**a) Vents.**

**(1)** Furnish cabinets containing a suitably designed rain tight vent or vents that:

- Are equipped with screens or filters, and
- Allow the release of excessive heat and/or any explosive gases which may enter the cabinet.

**(2)** Ensure when filters are utilized, positive retainment is provided on all sides to prevent warpage and entry of foreign matter around the edges.

**b) Vent Fan.**

Meet the following requirements:

- A thermostatically controlled vent fan is furnished to provide air circulation within the cabinet.
- The thermostat controlling the fan is manually adjustable to turn on between 90ºF and 150ºF (32ºC and 66ºC) with a differential of not more than 10ºF (6ºC) between automatic turn on and turn off.
- The fan is located with respect to the vent holes to direct the bulk of the air flow over the controller and auxiliary equipment.

**9) Connecting Cables, Wiring, and Panels.**

**a) Connecting Cables.**

Fabricate electrical connections from the controller (and auxiliary devices when included) to outgoing and incoming circuits in a manner that the controller (or auxiliary device) can be replaced with a similar unit, without the necessity of disconnecting and reconnecting the individual wires leading therefrom. This can be accomplished by means of a multiple plug, a spring connected mounting, or approved equivalent arrangement.

**b) Panels and Wiring.**

Furnish each cabinet with suitable, easily accessible wiring panel(s). Ensure all panel wiring is neatly arranged and firm, and all incoming cables are clearly identified by use of plastic numbered tags.

**(1) Wiring Terminals.**

Furnish terminals, as a minimum, for the following:

- Terminal with NEC approved cartridge fuse receptacle, fuse, power line switch, or magnetic circuit breaker, with integral power line switch, for the incoming power line,
- Terminal, unfused, for the neutral side of the incoming power line,
- Terminals and bases for signal load switches, flasher, and outgoing signal field circuits,
- Terminals for detector cables, and
- Terminals for all required auxiliary equipment.

**(2) Clearance between Terminals.**

Ensure adequate electrical clearance exists between terminals. Also ensure the controller, auxiliary equipment, panel(s), terminals, and other accessories are arranged within the cabinet so that they will facilitate the entrance and connection of incoming conductors.

**(3) Signal Circuit Polarity.**

Ensure the outgoing signal circuits are of the same polarity as the line side of the power service, and the

common return is of the same polarity as the grounded side of the power service.

**(4) Grounding Conductor Bus.**
Ensure an equipment grounding conductor bus is provided in each cabinet, and is grounded to the cabinet in an approved manner.

**10) Fusing and Surge Protection.**

**a) Incoming AC Line.**
Furnish suitable over-current protection, utilizing one of the methods described in Article 2525.03, E, 3, k, 9, b, 1.

**b) Lightning.**
Furnish suitable protection from lightning with lightning arresters, preferably of the gas filter type.

**11) Painting.**
Do not paint the aluminum exterior surface of the cabinet.

**4. Multi-Phase Traffic Actuated Controllers.**

**a. Operational Requirements.**

**1) Mode of Operation.**
Furnish controllers meeting the following requirements:

- Provide two to eight phase operation and are fully actuated with means for receiving actuations on all phases.
- Permit a nonactuated mode of operation on any of its phases by assertion of the vehicle recall function or pedestrian recall on the desired phase.

**2) Call to Nonactuated Mode.**
Furnish controllers that feature an input which, when asserted, permits the selection of nonactuated mode of operation on any of its phases.

**3) Operation with Auxiliary Functions/Devices.**
Furnish controllers capable of having their basic operation expanded or augmented by the addition of auxiliary functions or devices.

**4) Minimum Green.**

**a) Actuated Phase.**
The minimum green is to be the first timed portion of the green interval which is set in consideration of the storage of vehicles waiting between the sensing zone of the approach vehicle detector and the stop line.

**b) Nonactuated Phase.**
In the nonactuated mode of operation, the minimum green on the nonactuated phase is to be equal to the values described for Actuated Phases in the preceding paragraphs or equal to a separately set Minimum Green function.

**5) Unit Extension.**
Ensure the actuation of a vehicle detector during the extendible portion of an actuated traffic phase having the right-of-way causes the retention of right-of-way by that traffic phase for one Unit Extension portion from the end of the actuation, but subject to the Maximum (extension limit).

6) **Maximum (Extension Limit).**
Ensure the Maximum (extension limit) determines the maximum duration of time the right-of-way can be extended for a phase having successive detector actuations spaced less than a Unit Extension portion apart.

7) **Initiation of Maximum or Extension Limit.**
   a) Ensure the timing of the maximum or extension limit commences:
      - With the first actuation or other demand for right-of-way on a traffic phase not having the right-of-way, or
      - At the beginning of the Green interval if an actuation or other demand for right-of-way has been previously registered on a traffic phase not having the right-of-way.
   b) Alternatively, the maximum may commence at the end of the Initial portion of the Green interval if an actuation or other demand has been previously registered on a traffic phase not having the right-of-way.

8) **Transfer of Right-of-Way.**
Ensure the actuation of any detector on a traffic phase not having the right-of-way causes the transfer of the right-of-way to that traffic phase at the next opportunity in the normal phase sequence, provided there has been an expiration of:
   - A Unit Extension portion with no continuing actuation, or
   - The Maximum (extension limit) timing on the preceding phase having the right-of-way.

9) **Rest in Absence of Actuation.**
Ensure in the absence of detector actuation or assertion of recall switch(es), the right-of-way indication remains (rests) on the traffic phase on which the last actuation occurred.

10) **Memory Feature.**
Unless precluded by the operation of the nonmemory feature, the following memory retention is to be provided in the controller:
   If the right-of-way is transferred by the operation of the Maximum or extension limit, the traffic phase losing the right-of-way is to again receive it without further actuation at the next opportunity in the normal phase sequence.

11) **Pedestrian Timing Operation.**
Ensure the following pedestrian function operation is provided:
   a) **Condition in Absence of Pedestrian Call.**
   In absence of pedestrian actuation or assertion of pedestrian recall function, pedestrian signals remain in a DON'T WALK condition.
   b) **Pedestrian Actuation Memory.**
   Pedestrian actuations received by a phase during steady or flashing DON'T WALK indications of that phase are remembered and cause the controller to provide pedestrian timing functions for that phase at the next opportunity in the normal phase sequence.
   c) **Nonextension of Pedestrian Intervals.**

Successive pedestrian actuations do not cause extension of the pedestrian intervals.

**12) Other Operations Features.**

Ensure, in addition to specified functions, the following additional features are provided:

- All phase detector inputs are supplied with detector delay disable capability.
- All signal load outputs are individually fused with 10 ampere fuses.
- Detector test switches and pedestrian (if specified) test switches are provided for each phase.
- The permissive and force-off features are fully conditionable.

**b. Functional Requirements.**

Ensure, in addition to the basic functional requirements specified above, the controller provides the functional features for the applicable configuration included in NEMA Traffic Control Systems Standard TS-1.

**5. Coordination of Traffic Actuated Controllers.**

**a. Requirements.**

Furnish controllers with a means to permit their interconnection into a coordinated traffic signal system when coordinated devices are added. As a minimum, this should include the provision of yield circuit or hold circuit accessible to interruption by commands external to the controllers.

**1) Hold Feature.**

Ensure controllers contain a hold feature which, when asserted for a particular phase, holds that phase in a rest condition. Upon release from hold, the phase is to immediately advance into the appropriate clearance interval or other unexpired portion of the Green, provided there is an actuation or an opposing phase.

**2) Force-off Feature.**

Ensure controllers contain a force-off feature which, when asserted, causes termination of the current phase, provided that phase is in the extension portion. In no case is assertion of force-off to cause termination in a clearance interval or during a minimum Green for vehicles or pedestrians.

**3) Additional Features.**

Ensure the controllers and coordination devices are capable of, but not limited to, the additional coordination features, including:

- Three cycles,
- Four splits per cycle,
- Three offsets per cycle,
- Four permissible periods per split,
- Four force-offs per split,
- One pedestrian permissive period per vehicular permissive period, and
- One dwell period per cycle.

**b. NEMA Coordination Requirements.**
Ensure, in addition to the coordination requirements specified above, controllers contain tab coordination features for the applicable configuration included in NEMA Standard TS-1.

**6. Master-Secondary Controller.**

**a. Purpose.**
The purpose sets forth functional requirements which apply to an interconnected actuated controller which is also equipped to serve as a master controller. For this, the master controller shall be located as designated in the contract documents.

**b. Design Requirements.**
The general design requirements in Article 2525.03, G, 1 and 2 apply, in addition to specific functional requirements described below.

**c. Equipment.**
Ensure the master-secondary controller consists of a complete interconnected controller equipped with the necessary apparatus to provide supervisory functions for operation of a system of interconnected actuated and pretimed controllers.

**d. Supervisory Functions.**
Ensure the master controller is equipped with a solid state programmable plug-in module or controller accessory unit with time-based coordination capabilities. This unit is to provide as a minimum, but not limited to, these capabilities:

**1)** Synchronization pulse generation for offsets.
**2)** An offset interrupter or equivalent device for decreasing the disruption to interval timing caused by large offset changes.
**3)** Hand operated flash control switch for transfer of traffic control signal lights at each interconnected controller to give flashing indications.
**4)** Complete compatibility with actuated controller coordination units specified in Article 2525.03, E, 3.
**5)** Programming capability as a minimum, but not limited to, time of day, day of week, week of year, with daylight savings selection.

**F. Inductive Loop Vehicle Detector.**
Provide wiring and schematic diagrams, descriptive parts lists, and instruction and maintenance manuals for all items furnished under these specifications. Equipment or unit modifications as approved shall be accompanied by revised diagrams with the first shipment of the modified units. Provide tables, charts, or equations for use in designing loops of various sizes and configurations. Provide five complete sets of diagrams, manuals, and so forth to the Engineer with each order.

**1. Design Requirements.**
Meet the following requirements:

**a. Operation.**

**1) General.**

**a)** Detectors shall be designed to meet requirements of NEMA Traffic Control Systems Standard TS-1.

**b)** The detector shall provide reliable detection and maintain an output indication for a period of not less than 3 minutes for a vehicle that causes a 0.02% change in the total inductance of the loop and lead-in system, as measured at the detector loop input terminals.

**c)** The detector shall provide operation as above with a loop system having any or all of the following characteristics:

**(1)** A shunting resistance of 10,000 ohms or greater to a common or circuit ground bus.

**(2)** A loop system quality factor (Q) of not less than 5.0, when connected to the detector being tested. Q is defined as the ratio of the resonant operating frequency over the half-power band width.

**(3)** A total or equivalent inductance within the range of 40 microhenrys to 700 microhenrys at the detector loop input terminals.

**d)** A sensitivity adjustment or selector is to be provided to allow selection of a high, medium, or low sensitivity adjustment. Increments are to include: High, 0.02%; Medium, 0.06%, 0.01% (±); Low, 0.125%, 0.025% (±).

**2) Loop Energizing and Detector Sensing Circuits.**

**a)** The detector is to:

- Provide reliable detection of licensed motor vehicles,
- Provide an output (switch closure) only when vehicles are passing or stopped over the loop,
- Detect all vehicles passing over the loop at speeds up to 80 mph (130 km/h).

**b)** When first turned on, while tuning or being tuned, the detector shall provide a continuous output pulse (switch closure), plus a visual indication, in both the presence and pulse modes of operation. On power failure, or loop failure that would cause the inductance to exceed the tuning range, the detector shall place a continuous call.

**c)** To prevent mutual interference "cross-talk," the detectors shall be provided with a three-position frequency mode switch on the front panel.

**d)** The detector is to be designed to be initially tuned to the loop and provide for automatic drift compensation.

**e)** The operation of the detector shall not be affected by changes in the inductance of the loop caused by environmental changes, such as rain, hail, snow, temperature, and humidity, nor is the sensitivity to be markedly affected.

**3) Accuracy.**

The detector shall be able to detect all licensed vehicles, including motorcycles, accurately.

**b. Detector Output.**

The detector output (switch closure) to the associated traffic control equipment shall be provided by means of a relay. The relay shall have a mechanical life of at least 1,000,000 operations. The contacts are to have a rating of at least 1.0 ampere at 120 volts AC or DC.

**c. Power Supply.**

The primary of the power supply transformer shall be fused with a 1/4 inch (6 mm) diameter, 1 1/4 inch (32 mm) long, 250 volt fuse of suitable current rating. Provide an extractor-post fuse holder. The fuse rating shall be marked by the fuse holder.

**d. Visual Indicator.**

**1)** A LED shall be used to provide a visual indication of each vehicle detection. The indication shall be readily visible in indirect sunlight.

**2)** The LEDs are to have a minimum design life of 20,000 hours at rated voltage.

**e. Dielectric Strength.**

The detector shall withstand a dielectric strength test of 1250 volts, 60 hertz, AC applied between the 120 volt AC line-supply circuit and the terminals for the external loop, for a period of 1 minute.

**f. Interchangeability and Design Life.**

All modules and components of the same type shall be interchangeable. The design life of all components, under conditions of normal operation, is to be no less than 5 years.

**g. Marking.**

Each detector is to be marked with the manufacturer's name, model, catalog, or type number, and serial number. The electrical input rating (voltage, frequency, and wattage) is to be included in the marking.

**2. Input/Output Receptacle.**

**a. Function Assignment.**

Complete input and output connections for the detector to a type MS-3102-A-18-1P box receptacle using 10 male contacts. Place a plastic cover on the receptacle. Assign the pin positions of the input/output connector as follows:

| Pin No. | Function |
|---|---|
| A | 120 vac (-) |
| B | Output Relay Common |
| C | 120 vac (+) |
| D | Input from Loop |
| E | Input from Loop |
| F | Output Relay N.O. |
| G | Output Relay N.C. |
| H | Chassis Ground |
| I | Spare |
| J | Spare |

**b. Plug and Cable.**

Furnish a plug, type MS-3108-B with type 18-1S insert, with 10 female contacts, wired with leads of No. 18 AWG stranded, color-coded wire with 300 volt insulation. Furnish a type MS-3057-10 cable clamp and boot for strain relief. Fabricate the leads to be 10 feet (3 m) long, with the first 16 inches (0.4 m) of leads, from the plug, enclosed in cotton braiding. No terminals are required on the leads.

3. **Components.**

   a. **Inductors and Transformers.**
   Ensure all inductors and transformers have their windings insulated and are impregnated to exclude moisture. Ensure all wire leads are color coded.

   b. **Resistors and Capacitors.**
   Ensure all resistors and capacitors are insulated and marked with their resistance or capacitance value. Resistance and capacitance values may be indicated by the Radio Electronics Television Manufacturer's Association (RETMA) color codes. Ensure all electrolytic capacitors are marked to indicate polarity and voltage.

   c. **Printed-Circuit Boards.**
   Ensure the following:
   - All printed-circuit boards are at least 1/16 inch (1.5 mm) thick and made of glass-cloth silicone NEMA type G-10 glass epoxy, or equivalent.
   - The conductor material is copper, 0.0027 inch (70 µm) thick, having a weight of 2.0 ounces per square foot (610 g/m$^2$), with a protective solder coating.
   - All printed-circuit board connectors (male and female) are gold plated over the copper base.
   - The printed circuit-boards are securely mounted to prevent flexing or bending of the boards, and are easily removable for servicing or replacement.

   d. **Wiring.**
   Use No. 22 AWG, or larger, insulated interconnecting wires, suitable for 180ºF (82ºC) operation.

   e. **Solid State Circuitry.**
   **1)** Meet the following requirements:
   **a)** Transistors, integrated circuits, or semiconductor diodes shall be used for all amplifying, detecting, rectifying, counting logic, and regulator circuits. No vacuum or gas tubes are to be used except for pilot lights. Transistors, integrated circuits, and diodes are to be marked with their type number and are to be types listed by the RETMA.
   **b)** No electro-mechanical timers, synchronous motors, or relays shall be employed, except as specified in Article 2525.03, A.
   **c)** All electronic and electrical components shall be of standard manufacture and available from a source other than the manufacturer of the loop detector unit.
   **2)** No modifications to the circuit, parts substitutions, or changes in the function or form from the original equipment list will be allowed without prior approval of the Engineer.

4. **Detector Loop Installation.**

   a. Insert the detector loop wire into a flexible plastic tubing for the full length of the wire from the point of splicing. Prefabricated loops installed under new paving consist of loop wiring encased in a watertight plastic tubing assembly. The field loop conductors installed in the pavement are to run continuously from the

terminating service box or base with no splices permitted. At the time of placing the loop wire in the sawed slots, seal the ends of the tubing to prevent moisture from entering the tubing.

**b.** Twist all lengths of loop wires and tubing not imbedded in the pavement with at least 5 turns per foot (16 turns per meter), including lengths in conduit and service boxes.

**c.** Solder the electrical splice between the loop and lead-in cable to the controller and the loop wire using resin core solder. Furnish a water tight protective covering for the spliced wire, the shielding on the loop lead-ins and the end of the tubing containing the loop wires. Using an open flame to heat the wire connection will not be permitted. Use a soldering iron, gun, or torch equipped with a soldering tip. Complete the splice using the following method:

**1)** Remove all lead-in cable coverings leaving 4 inches (100 mm) of insulated wire exposed.

**2)** Remove the insulation from each conductor of a pair of lead-in cable conductors and scrape both copper conductors with knife until bright.

**3)** Remove the plastic tubing from the loop wires for 1.5 inches (40 mm).

**4)** Remove the insulation from the loop wires and scrape both copper conductors with knife until bright.

**5)** Connect conductors by a soldered “Western Union” type splice, wrapped with water proof tape and coated with a water tight protective covering.

**6)** Cover the exposed shielding, ground wire and end of any unused loop lead-in where the sheathing was cut with liquid silicone rubber. Apply Butyl Rubber Polymer Tape sealant between the wires and completely cover the silicone rubber. 3M Company Scotchcast Kit, or approved equal, is an acceptable alternate for splices.

**d.** Mark the location of each loop on the pavement with crayon or spray paint. Obtain the Engineer’s approval prior to cutting the saw slots.

**e.** Use a saw equipped with a depth gage and horizontal guide to assure proper depth and alignment of the slot. Use a blade for the saw cut that will provide a clean, straight, well defined 3/8 inch (10 mm) wide saw cut, without damage to adjacent areas. Make cuts 1.5 inches to 2 inches (40 mm to 50 mm) deep. Where the loop changes direction, overlap the saw cuts to provide full depth at all corners. Do not use right angles or corners less than 90 degrees.

**f.** Before installing the loop wire, check the saw cuts for the presence of jagged edges or protrusions. If they exist, remove them. Clean and dry the slots to remove cutting dust, grit, oil, moisture or other contaminants. Clean by flushing with a stream of water under pressure, followed by an air blast using oil free compressed air.

**g.** Install loop detector conductor using a nominal 0.2 inch (5 mm) thick wood paddle. If the wire does not lie close to the bottom of the saw cut, hold it down using a material such as tape or doubled over pieces of the plastic tubing.

**h.** Coil each loop clockwise (or according to the manufacturer's recommendations) and band the beginning conductor in the

terminating handhole or base with a symbol "S" to denote the start of conductor. Use durable tags to further identify each loop by phase or function as shown in the contract documents.

**i.** Connect the “S” conductor of the loop to the unbanded conductor of the adjacent loop for situations where multiple loop configurations, spliced to a single lead-in loop, are to be connected in series.

**5. Detector Loop Sealing.**

**a.** After obtaining satisfactory test results, seal the loop with a flexible embedding sealer listed in Materials I.M. 491.18. Use the sealer according to the manufacturer's instructions.

**1)** Pour the sealer into the slot to half depth.

**2)** When both the loop and lead-in slots are half filled, check for air bubbles and material pileup, and then proceed to fill the slots to roadway level. The sealer, when poured into a saw cut, should completely surround the wires, displace all air and completely fill the area of the slot, except for that portion filled with the wire hold down material.

**3)** Remove excess sealant using a squeegee. Ensure neither a trough or a mound remains.

**4)** Allow sufficient time for the sealer to harden, according to manufacturer's instructions, before allowing traffic to move over the area.

**b.** After completion of the sealing, test the loop individually at the handhole and as a group at the control cabinet. The completed sealed loop is required to pass continuity, inductance, and resistance testing prior to being accepted.

**6. Detector Loop Testing.**

Test all loops and document by using the following procedures:

**a.** Determine the insulation resistance of the loop wire using a "megohmmeter" with 500V applied to either loop wire to earth ground. The resistance is to be greater than 100 megohms.

**b.** Determine the inductance of the loop using a loop inductance meter.

## G. Signals.

**1. General.**

**a.** Furnish traffic signals manufactured in polycarbonate sections that are interchangeable and fit so they can be combined in a tier. Follow the requirements as shown in the contract documents for mounting devices, lens indications, and other modifications. Ensure the reflector is parabolic in design and made of specular alzak aluminum. Other parts of the optical system, including the lens, lamp socket, reflector, and reflector holder, are to be manufactured as a whole system so as to eliminate the return of outside light rays which enter the unit.

**b.** During the course of construction and until the signals are placed in operation, cover signal faces or turn them away from approaching traffic. When ready for operation, secure them in position facing toward approaching traffic.

**c.** Ensure the optical assembly of the vehicle signals is in substantive compliance with the latest version of ITE Standard for Adjustable Face Vehicle Traffic Control Signal Heads.

**d.** Apply one prime coat of metal primer and two coats of high quality Federal yellow enamel to mounting accessories. Dipping will not be permitted for any part of the enameling process. Ensure mounting accessories for mast-arm mounted signal fixtures are galvanized in accordance with the latest revision of ASTM A 123. The body of the signal sections is to be Federal yellow, and the door, backplate, if required, and visors are to be dull black. The color shall be completely impregnated in the polycarbonate material, and scratches are not to expose uncolored material.

**2. Vehicle Signals.**

Meet the following requirements:

**a.** All lenses shall be of the prismatic, long range type. The lenses shall have a nominal diameter of 12 inches (300 mm). All lenses shall be made of vandal resistant polycarbonate or acrylic plastic meeting the light transmitivity and chromaticity standards established by latest version of 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% of the lens circumference for the entire length of the visor. Cut-a-way type visors shall be provided for each lens of optically programmed sections only where specifically required as indicated in the contract documents.

**c.** Mastarm mounted vehicle heads shall be equipped with a backplate. The backplate shall provide a minimum of 5 inches (125 mm) of black field around the assembly.

**3. Pedestrian Signals.**

Meet the following requirements:

**a.** Pedestrian signals shall consist of two signal sections with rectangular lenses and mounting attachments as shown in the contract documents. The upper section shall display a DON'T WALK symbol, and the lower shall display a WALK symbol. The two sections are to 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 0.5 inch (13 mm) thick. These signals are intended to operate with incandescent lamps.

**b.** The lenses shall be either sanded or prismatic lenses of nominal 9 inch or 12 inch (225 mm or 300 mm) size, as indicated in the contract documents. The lenses shall be made of vandal resistant polycarbonate or acrylic plastic. The symbols on these lenses shall be designed to produce maximum legibility both day and night. The WALK symbol shall be Lunar White, and the DON'T WALK symbol is to be Portland Orange. Both messages shall be screened on the lenses with a material which will not crack or peel. The background or field around both messages is to be black.

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

**4. Traffic Signal Lamp.**

All traffic signal lamps shall have a standard, medium brass screw base and a clear glass envelope. The light center length (L.C.L.), or the dimension, in inches (millimeters), from the center of the filament to the tip of the base, is to be in compliance with the following design requirements:

**a.** 67 Watt series (9 inch (225 mm) pedestrian heads)

- Light center length — 2 7/16inch (62 mm)
- Rated life hours — 8000 hours
- Rated initial lumens — 665 lumens
- Minimum initial lumens — 595 lumens
- Rated voltage — 120 volts

**b.** 150 Watt series (for 12 inch (300 mm) traffic and pedestrian heads)

- Light center length — 3 inch (75 mm)
- Rated life hours — 6000 hours
- Rated initial lumens — 1950 lumens
- Minimum initial lumens — 1745 lumens
- Rated voltage — 130 volts

**5. Optically Limiting Signals.**

**a. General.**

Ensure the signal permits the visibility zone of the indication to be determined optically without a need for hoods or louvers. The projected signal may be visible or selectively veiled anywhere within 15 degrees of the optical axis. No indication is to result from external illumination, nor is one indication to illuminate a second.

**b. Optical System.**

Meet the following requirements:

**1)** The components of the optical system are to consist of:
Lamp
Circlet Reflector
Optical Limiter-Diffuser
Objective Lens

**2)** The lamp shall be a nominal 150 watt, 120 volt AC, three prong, sealed beam having an integral reflector and an average rated life of 6,000 hours.

**3)** A circlet reflector with a specular inner surface is to mate the lamp to the diffusing element.

**4)** The optical limiter-diffuser combination shall provide an imaging surface, at focus on the optical axis for objects 900 feet to 1,200 feet (270 m to 370 m) distance. It is also to permit an effective veiling system to be variously applied as determined by the desired visibility zone. The optical limiter-diffuser shall be provided with positive indexing means and to be composed of heat resistant glass.

**5)** The objective lens shall be a high resolution planar incremental lens, hermetically sealed within a flat laminate of weather resistant acrylic. The lens shall be symmetrical in outline and may be rotated to any 90 degree orientation about the optical

axis. Lens colors shall comply with ITE transmittance and chromaticity standards.

c. **Castings.**
Ensure cast aluminum parts comply with ITE alloy and tensile requirements and have a chromate preparatory treatment. The exterior of the signal case, lamp housing, and mounting flanges shall be finished with a high quality flat black enamel prime and finish system. The lens cover and the interior of the case shall be optical black. Hinge and latch pins shall be stainless steel. All access openings shall be sealed with weather resistant rubber gaskets.

d. **Visors.**
Ensure visors are 9 1/2 inch (240 mm), cut-a-way visors, are optical black, and are attached to all optically limiting signals for this project.

e. **Installation.**
Install, direct, and veil the signal according to published instructions and the Engineer's approval. Mask each section of the signal as required with prescribed materials in an acceptable and competent manner.

6. **Pedestrian Push Button Detectors.**
Furnish pedestrian push button detectors of the direct push contact type without levers, handles, or toggle switches. Meet the following requirements:

**a.** Each detector shall consist of a removable contact assembly mounted in a durable metal case.

**b.** The contacts shall be entirely insulated from the case and operating button with terminals for making connections.

**c.** The case shall have one outlet for 0.5 inch (13 mm) pipe.

**d.** The operating button is to be made of brass or other nonrusting metal alloy and be of sturdy design.

**e.** This button shall be weatherproof and is not to protrude out from the case.

**f.** The entire assembly shall be weather tight, secured against electrical shock and of such construction to withstand continuous hard usage.

**g.** The contacts shall be normally open, with no current flowing except at the moment of actuation.

## H. Signal Supports (Single Tubular Mastarms and Poles).

1. **General.**
Meet the following requirements:

**a.** Furnish mastarms and support poles that are continuous tapered, round steel poles of the anchor base type as shown in the contract documents. The poles and mastarms shall be fabricated from one length of steel sheet with one continuous arc welded vertical seam, unless approved otherwise by the Engineer.

**b.** Unless specified otherwise, the poles and mastarms shall be fabricated from low carbon steel (maximum carbon, 0.30) of U.S. standard gage The base and flange plates shall be of structural

steel complying with AASHTO M 183 (ASTM A 36/A 36M) and cast steel complying with ASTM A 27/A 27M, Grade 70-36 or better.

**c.** When specifically required, the poles and mastarms shall be fabricated from corrosion resistant steel meeting requirements of ASTM A 595, Grade C, and A 606, Type 4 sheets (with minimum chemical requirements of ASTM A 588/A 588M, Grade D). The base and flange plates shall be fabricated from A 588/A 588M structural steel.

**d.** After manufacture, poles and mastarms shall have a minimum yield strength of 48,000 psi (330 MPa).

**e.** It may be permissible to fabricate poles and mastarms by welding two sections together. The method used for connecting the sections shall result in a smooth joint and be factory welded.

**1)** Longitudinal butt welds, except within 1 foot (0.3 m) of a transverse butt-welded joint, shall have a minimum 60% penetration for plates 3/8 inch (10 mm) and less in thickness, and a minimum of 80% penetration for plates over 3/8 inch (10 mm) in thickness.

**2)** Longitudinal butt welds on poles and arms within 1 foot (0.3 m) of a transverse butt-welded joint shall have 100% penetration.

**3)** Transverse butt welds for connecting sections shall have 100% penetration achieved by back-up ring or bar.

**4)** Transverse butt welds and all specified 100% penetration longitudinal butt welds on poles and mastarms shall be examined 100% by ultrasonic inspection.

**f.** In addition, welding, fabrication, and inspection shall comply with Article 2408.03, B.

**g.** Personnel performing nondestructive testing are required to be qualified according to the American Society for Nondestructive Testing Recommended Practice No. SNT-TC-1A and applicable Supplements B (Magnetic Particle) and C (Ultrasonic). The welding consumables used shall comply with Materials I.M. 559.

**h.** The poles and mastarms shall be designed to support traffic signals, luminaires, and/or signs as shown in the contract documents. They shall be certified by the fabricator that the poles and mastarms are capable of withstanding winds up to 100 mph (160 km/h) without failure.

**i.** The poles and mastarms shall be galvanized inside and out according to ASTM A 123.

**j.** Erect all poles vertically, unless otherwise specified.

**1)** Securely bolt bases to the cast-in-place concrete foundations.

**2)** Perform leveling using two nuts on each anchor bolt. One nut shall be turned on each anchor bolt and the pole placed in position on these nuts. The top nut shall then be turned into place loosely and the pole adjusted to the vertical position by adjusting both the upper and lower nuts.

**3)** After leveling the poles, trowel mortar between the pole base and the foundation. Use expansive type mortar. Neatly finish exposed edges of mortar.

**4)** Ground each pole by installing a No. 6 AWG bare copper ground wire between the pole and the ground rod according to Article 2523.03, M.

5) Perform electrical tests according to Article 2523.03, U.

2. **Concrete Bases for Poles.**
   a. For the forms, use material of sufficient thickness to prevent warping or other deflections from the specified pattern.
   b. Set the forms level, and provide means for holding them rigidly in place while the concrete is being deposited.
   c. Rigidly install all conduit, ground rods, and anchor rods in place before concrete is deposited in the forms.
   d. Place anchor bolts according to Article 2405.03, H, 3. Set anchor bolts for the signal poles in place by means of a template constructed to space the anchor bolts according to the manufacturer's requirements.
   e. The center of the template and the center of the concrete base are to coincide.
   f. For concrete, apply Section 2403.
   g. Finish the top of the base to be level and round the top edges with an edger having a radius of 0.5 inch (13 mm).
   h. Set the top of pole bases flush with the sidewalk or pavement surface. When installed in an earth shoulder away from the pavement edge, set the concrete base so the top is approximately 4 inches (100 mm) above the surface of the ground. Finish the exposed surface of the base with a wood float.

3. **Hardware.**
   Ensure mastarms and poles are equipped with all necessary hardware, shims, and anchor bolts to provide for a complete installation without additional parts. The fabricator shall submit drawings for anchor bolts and base design. All hardware shall be steel, hot-dipped galvanized according to ASTM F 2329; or ASTM B 695, Class 50, Type I coating, or shall have an electro deposited coating of the same coating thickness, and so designed for this purpose.
   a. **Anchor Bolts.**
      - Full-length, full-body diameter, hot-dip galvanized meeting the requirements of ASTM F 1554, Grade 105 (724 MPa).
      - Threaded a minimum of 6 inches (150 mm) at one end, with a 4 inch (100 mm) long, 90 degree bend at the other end.
      - Unified Coarse Thread Series with Class 2A tolerance.
      - The end of each anchor bolt shall project from the concrete color coded in red to identify the grade.
   b. **Nuts.**
      - Heavy hex meeting the requirements of ASTM A 563, DH.
      - May be over-tapped according to the allowance requirements of ASTM A 563.
   c. **Washers.**
      Meet the requirements of ASTM F 436.

4. **Aluminum Traffic Signal Pedestal.**
   Meet the following requirements for the pedestal shaft:
   a. Fabricated from tubing with a wall thickness of no less than 0.125 inches (3 mm).

**b.** Equipped with a cast aluminum base with a handhole. The size of the handhole shall be at least 4 inches by 6 inches (100 mm by 150 mm). It shall be equipped with a cover which can be securely fastened to the shaft with the use of hand tools.

**c.** The top of the shaft shall have an outer diameter of 4.5 inches (115 mm).

## I. Testing of Signal Equipment.

**1.** After the project is open to traffic, notify the Engineer in writing of the date the signal or signal system will be ready for testing. Upon concurrence of the Engineer, place the signal or signal system in operation for a consecutive 30 calendar day test period. If the signal is to operate independently of other signals or signal systems, test it as a single installation. If the signal is part of a system, do not start the test period until all signals in the system are ready to be tested. Test a system as a unit. Correct all failures or malfunctions of the equipment during the test period at no additional cost to the Contracting Authority. The Contractor will not be required to pay for energy consumed by the system, and working days will not be charged during this testing period.

**2.** Secure the services of an authorized factory representative of the controller manufacturer to check out the system and to make all necessary adjustments at the time the equipment is turned on in order to get all specified functions of the equipment working properly. The factory representative shall have on hand, at the time the equipment is turned on, the necessary tools, test equipment, spare modules, spare detector amplifiers, and other miscellaneous parts and equipment to check out the system and make all necessary adjustments. Notify the Engineer at least two business days prior to turn on so the Engineer may be present at the turn on.

## J. Certification of Equipment.

Supply certification from the manufacturers of all electrical equipment, signal supports, conduit, and cable stating the materials comply with the specifications.

## K. Documentation.

**1.** With each signal system, provide file documentation packages which consist of the following:

**a.** Complete schematic diagram, accurate and current for units supplied.

**b.** Complete physical description of units.

**c.** Controller printout or equal documentation of initial controller settings installed in the field or in the office.

**d.** Complete installation procedure and performance specifications, both electrical and mechanical, for loop detector amplifier units.

**e.** Complete maintenance and trouble-shooting procedures.

**f.** Standard industry warranties on units supplied.

**g.** Complete parts list identifying full names of vendors for parts not identified by universal part numbers such as JEDEC, RETMA, or EIA.

**h.** Pictorial of components layout on chassis or circuit board.

**2.** Include at least one full package in each controller cabinet and provide the Engineer with one full package.

**2525.04 METHOD OF MEASUREMENT.**

None. Plan quantities are for estimating purposes only, and these quantities will not be paid for separately.

**2525.05 BASIS OF PAYMENT.**

**A.** Payment for Traffic Signalization will be made at the lump sum contract price.

**B.** Removal of the existing traffic signal installation will be paid for at the lump sum price for Removal of Traffic Signalization. The lump sum price for Removal of Traffic Signalization will be full payment for the removal of all traffic signal poles, signal pole footings, overhead wires, handholes, and controllers. Removal of underground wire, cable, and conduit will not be required.