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(NEW)

Iowa Department of Transportation

SPECIAL PROVISIONS
FOR
TRAFFIC SIGNALIZATION

Pottawattamie County
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THE STANDARD SPECIFICATIONS, SERIES 2012, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

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A. NEMA TS 2 ACTUATED TRAFFIC SIGNAL CONTROLLER UNIT

The Actuated Controller, Cabinet, and all auxiliary equipment shall be in full compliance with the NEMA Standard TS2 Type 2 requirements.

The local intersection controller shall be the most current version of the Siemens ITS M50 series controller or an equivalent approved by the City Traffic Engineer. The controller shall include the data key option or similar function. The local intersection Controller shall be capable of operating in the City of Council Bluff's existing MARC 360 Closed Loop System manufactured by Siemens ITS, and be capable of communicating with the City's current central system software. The Controller shall be capable of 10/100 BASE-T Ethernet network communication.

All auxiliary equipment supplied in the signal cabinet not produced by the primary Controller manufacturer shall have service information and parts availability information supplied including, model number, serial number, and/or part number, and the address of the manufacturer included on the cabinet layout and master parts list. The same manufacturer as the Controller timing unit shall manufacture the cabinet terminal facilities. All other equipment may be multi-source. Refer to the latest version of NEMA Standard TS2, Type 2 for further standards and specifications for TS2 signal equipment.

B. MALFUNCTION MANAGEMENT UNIT

This section sets forth the minimum requirements for a shelf-mountable, sixteen channel, solid-state Malfunction Management Unit (MMU). The MMU shall meet, as a minimum, all applicable sections of the latest version of the NEMA TS2 standards. An independent testing laboratory shall verify that the MMU will perform all its defined functions under the conditions set forth in Section 2 of the NEMA STANDARD (Environmental Standards and Test procedures). Where differences occur, this specification shall govern.

HARDWARE ENCLOSURE:
The MMU shall be compact so as to fit in limited cabinet space. It shall be installable on a shelf that is at least 7 inches deep. Overall dimensions, including mating connectors and harness, shall not exceed 10.5 inches H by 4.5 inches W by 11 inches D.

The enclosure shall be constructed of sheet aluminum with a minimum thickness of 0.062 inches, and shall be finished with an attractive and durable protective coating. Model, serial number, and program information shall be permanently displayed on the rear surface.

ELECTRONICS:
A microprocessor shall be used for all timing and control functions. Continuing operation of the microprocessor shall be verified by an independent monitor circuit, which shall force the OUTPUT RELAY to the de-energized "fault" state and indicate an error message if a pulse is not received from the microprocessor within a defined period.

In the interest of reliability, only the PROM memory device for the microprocessor firmware shall be socket mounted. The PROM Memory socket shall be a precision screw machine type socket with a gold contact finish providing a reliable gas tight seal. Low insertion force sockets or sockets with "wiper" type contacts shall not be acceptable.

A built-in, high-efficiency power supply shall generate all required internal voltages. All voltages shall be regulated and shall be monitored with control signals. Failure of the internal power supply to provide proper operating voltages shall force the OUTPUT RELAY to the de-energized "fault" state and indicate an error message. A front panel mounted fuse shall be provided for the 120 VAC input.

User-programmed configuration settings shall be stored in an electrically erasable programmable read-only memory (EEPROM) or via front panel DIP switches. Designs using a battery to maintain configuration data shall not be acceptable.

All 120 VAC field terminal inputs shall provide an input impedance of at least 150K ohms and be terminated with a resistor having a power dissipation rating of 0.5 Watts or greater. Each 120 VAC field terminal input shall be sensed by a separate precision voltage comparator device.

All electrical components used in the MMU shall be rated by the component manufacturer to operate over the full NEMA temperature range of -30°C to +74°C.

All printed circuit boards shall meet the requirements of the NEMA Standard plus the following requirements to enhance reliability:

- All plated-through holes and exposed circuit traces shall be plated with solder.
- Both sides of the printed circuit board shall be covered with a solder mask material.
- The circuit reference designation for all components and the polarity of all capacitors and diodes shall be clearly marked adjacent to the component. Pin #1 for all integrated circuit packages shall be designated on both sides of all printed circuit boards.
- All electrical mating surfaces shall be gold plated.
- All printed circuit board assemblies shall be coated on both sides with a clear moisture-proof and fungus-proof sealant.

FRONT PANEL & CONNECTORS:
All displays, configuration switches, and connectors shall be mounted on the front panel of the MMU. All MMU configuration inputs beyond those required by the NEMA Standard shall be provided by front panel mounted DIP switches and shall be clearly labeled. Configuration DIP switches shall be provided for the following functions:

- Field Check / Dual Enables l- 16.
- Green/Yellow-Dual Indication Enable.
- BND Test Disable.
- External Watchdog Enable.

The connectors on the MMU shall have a metallic shell and be attached to the chassis internally. They shall be manufactured to meet MIL-C-26482 specifications. The connectors shall be mounted on the front of the unit in accordance with the following: Connector A shall intermate with a MS 3116 22-55 SZ, and Connector B shall intermate with a MS 3116 16-26 S.

In the interest of reliability and reparability, printed circuit board mounted MS connectors shall not be acceptable. Internal MS harness wire shall be a minimum of AWG #22, 19 strands.

All indicator lights shall be water clear, T-1 package, Red Super Bright type LEDs. Indicators shall be provided for the following items:

- Flashing Yellow Arrow Protective Permissive Monitoring
- Channel Status 1-16
- Conflict
- Red Fail
- CVM / External Watchdog
- 24V-2
- 24V-1
- Clearance Fail
- Port 1 Fail
- Diagnostic / Program Card
- Field Check Fail
- Dual Indication
- Type 12 mode
- Power
- Port 1 Receive
- Port 1 Transmit

OPERATING MODES:
The MMU shall operate in both the Type 12 mode and Type 16 mode as required by the NEMA Standard.

MONITORING FUNCTIONS:
The following monitoring functions shall be provided in addition to those required by the NEMA Standard Section 4.

FLASHING YELLOW ARROW PROTECTIVE PERMISSIVE MONITORING:
The MMU shall monitor an intersection with up to four approaches using the four section Flashing Yellow Arrow (FYA) movement on Protected/Permissive signal displays with FYAs. The MMU shall provide the same fault coverage for the FYA approaches as it does for conventional movements including Conflict, Red Fault, Dual Indication, and Minimum Clearance Monitoring. For monitoring purposes, the FYA approach is logically defined as a four input “channel” consisting of the solid red arrow, solid yellow arrow, flashing yellow arrow (permissive), and solid green arrow (protected). One additional load switch is required for each FYA approach to be monitored.

DUAL INDICATION MONITORING:
Sixteen switches labeled FIELD CHECK/DUAL ENABLES shall be provided on the MMU front panel to enable Dual Indication Monitoring on a per channel basis. The Dual Indication Monitor function shall provide two modes of operation, Dual Indication Fault and Green/Yellow-Dual Indication Fault.

When voltages on two inputs of a channel are sensed as active for more than 1000 msec, the MMU shall enter the fault mode, transfer the OUTPUT relay contacts to the Fault position, and illuminate the DUAL INDICATION indicator. The MMU shall remain in the fault mode until the unit is reset by the RESET button or the EXTERNAL RESET input. When voltages on two inputs of a channel are sensed as active for less than 700 msec, the MMU shall not transfer the OUTPUT relay contacts to the Fault position.

When operating in the Type 16 mode with Port 1 communications enabled, Bit #68 (Spare Bit #2) of the Type #129 response frame shall be set to indicate a Dual Indication fault has been detected.

Dual Indication Monitoring shall be disabled when the RED ENABLE input is not active. When operating in the Type 16 mode with Port 1 communications enabled, Dual Indication Monitoring shall also be disabled if the LOAD SWITCH FLASH bit is set to "1" in the Type #0 message from the Controller Unit.

DUAL INDICATION MONITOR: Dual Indication monitoring shall detect simultaneous input combinations of active Green (Walk), Yellow, or Red (Don't Walk) field signal inputs on the same channel. In Type 12 mode this monitoring function detects simultaneous input combinations of active Green and Yellow, Green and Red, Yellow and Red, Walk and Yellow, or Walk and Red field signal inputs on the same channel.

GREEN YELLOW-DUAL INDICATION MONITOR: Green Yellow-Dual Indication monitoring shall detect simultaneous inputs of active Green and Yellow field signal inputs on the same channel. It will be used to monitor channels which have an unused Red field signal input tied to AC LINE such as a five section signal head.

Green Yellow-Dual Indication Monitoring shall be enabled by a front panel option switch. When the Green Yellow-Dual Indication Monitoring option is enabled, all channels which have the front panel FIELD CHECK/DUAL ENABLE switches OFF shall be individually monitored for simultaneous active Green and Yellow field signal inputs. All channels which have the front panel FIELD CHECK/DUAL ENABLE switches ON (i.e., enabled for Dual Indication Monitoring) shall function as described above in Dual Indication Monitoring.

FIELD CHECK MONITORING:

Sixteen switches labeled FIELD CHECK/DUAL ENABLES shall be provided on the MMU front panel to enable Field Check Monitoring on a per channel basis. The Field Check Monitor function shall provide two modes of operation, Field Check Fault and Field Check Status.

Field Check Monitoring shall be disabled when the RED ENABLE input is not active. When operating in the Type 16 mode with Port 1 communications enabled, Field Check Monitoring shall also be disabled if the LOAD SWITCH FLASH bit is set to “1" in the Type #0 message from the Controller Unit. The Field Check Monitoring function shall be disabled in the Type 12 mode.

FIELD CHECK MONITOR:
In the Field Check Fault mode, when the field signal input states sensed as active or inactive by the MMU do not correspond with the data provided by the Controller Unit in the Type #0 message for ten consecutive messages, the MMU shall enter the fault mode, transfer the OUTPUT relay contacts to the Fault position, and illuminate the FIELD CHECK FAIL indicator. The Channel Status Display shall indicate the channels on which the Field Check fault was detected. Bit #67 (Spare Bit #1) of the Type #129 response frame shall be set to indicate a Field Check fault has been detected. The MMU shall remain in the fault mode until the unit is reset by the RESET button or the EXTERNAL RESET input.

FIELD CHECK STATUS :
The Field Check Status mode shall work in combination with the other fault monitoring functions of the MMU. When a Conflict, Red Fail, Clearance Fail, or Dual Indication Fail triggers the MMU, the Channel Status Display and Fault Status Display shall correspond to that detected fault. If Field Check errors were detected while the fault was being timed, the FIELD CHECK FAIL indicator shall illuminate and double pulse once every 2 seconds. The channels on which the Field Check errors were detected shall double pulse at the same time as the FIELD CHECK FAIL indicator. Bit #67 (Spare Bit #1) of the Type #129 response frame shall also be set to indicate Field Check errors have been detected.

BND ERROR DETECTION MONITORING:
The BND Error Detection function shall be designed to detect and respond to irregular field input waveforms such as: irregularly blinking (flickering); having constant extraneous noise; being dimmed invalidly under Controller Unit software control.

Detection of a BND Error shall place the MMU into the fault mode, transfer the OUTPUT relay contacts to the Fault position, and illuminate the BND FAIL indicator. The Channel Status display shall indicate the channels on which the fault occurred. When operating in the Type 16 mode with Port 1 communications enabled, Bit #69 (Spare Bit #3) of the Type # 129 response frame shall be set to indicate a BND Error Detection fault has been detected. The MMU shall remain in the fault mode until the unit is reset by the RESET button or the EXTERNAL RESET input. An MMU Power Failure shall reset the BND Fail fault state of the monitor.

EXTERNAL WATCHDOG MONITOR:
The MMU shall provide the capability to monitor an optional external logic level output from a Controller Unit or other external cabinet circuitry. If the MMU does not receive a change in state on the EXTERNAL WATCHDOG input for 1500 msec (+/-100 msec), the MMU shall enter the fault mode, transfer the OUTPUT relay contacts to the Fault position, and illuminate the CVM/WATCHDOG indicator. The MMU shall remain in the fault mode until the unit is reset by the RESET button or the EXTERNAL RESET input. An MMU Power Failure shall reset the CVM/WATCHDOG fault state of the monitor.

When operating in the Type 16 mode with Port 1 communications enabled, Bit #70 (Spare Bit #4) of the Type # 129 response frame shall be set to indicate an External Watchdog fault has been detected.

TYPE FAULT MONITOR:
The MMU shall verify at power-up that the Type 12 or Type 16 operating mode as determined by the TYPE SELECT input is consistent with the mode set by the last external reset.

Detection of a Type Fault shall place the MMU into the fault mode, transfer the OUTPUT relay contacts to the Fault position, illuminate the DIAGNOSTIC indicator, and flash the TYPE 12 indicator at a 2Hz rate.

The MMU shall remain in the fault mode until the unit is reset by the RESET button or the EXTERNAL RESET input. An MMU Power Failure shall reset the Type Fault state of the monitor.

DISPLAY FUNCTIONS:
The following display functions shall be provided in addition to those required by the NEMA Standard Section 4.

YELLOW PLUS RED CLEARANCE INTERVAL DISPLAY:
The MMU Channel Status display shall indicate with a steadily illuminated LED indicator, those channels which had the short Yellow plus Red interval (i.e., those channels which did not meet the minimum Yellow Change plus Red Clearance Interval). The conflicting channel(s) which was sensed active Green causing the Minimum Yellow Change plus Red Clearance Fault shall also be indicated with a single pulsed LED indicator.

PORT 1 TRANSMIT INDICATOR:
The TRANSMIT indicator shall illuminate whenever the MMU has the Port 1 transmitter enabled.

PROGRAM CARD INDICATOR:
The DIAGNOSTIC/PGM CARD indicator shall flash at a 2Hz rate if the Programming Card is absent or not seated properly in its mating connector.

ADDITIONAL FEATURES:
The MMU shall include both automatic and operator initiated diagnostics.

Automatic diagnostics shall verify memory and microprocessor operation each time power is reapplied to the MMU. After power has been applied, diagnostics shall continually verify the operation of essential elements of the MMU including at a minimum: PROM, EEPROM, communications, internal power supply, and the microprocessor.

Operator initiated diagnostics shall allow the operator to verify proper operation of all indicator lights, PROM, EEPROM, RAM and microprocessor.

C. TS2 TYPE 1 CABINET ASSEMBLY

This section sets forth the minimum requirements for a TS2 Type 1 traffic control cabinet assembly. The cabinet assembly shall meet, as a minimum, all applicable sections of the NEMA Standard Publication No. TS2-1992. Where differences occur, this specification shall govern.

CABINET DESIGN AND CONSTRUCTION:
The cabinet shall be constructed from type 5052-H32 aluminum with a minimum thickness of 0.125 inches.

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

A rain channel shall be incorporated into the design of the main door opening to prevent liquids from entering the enclosure. The cabinet door opening must be a minimum of 80% of the front surface of the cabinet.

The top of the cabinet shall incorporate a 1 inch slope toward the rear to prevent rain accumulation. Unless otherwise specified, the cabinet shall be supplied with a natural aluminum finish.

Sufficient care shall be taken in handling to ensure that scratches are minimized. All surfaces shall be free from weld flash. Welds shall be smooth, neatly formed, free from cracks, blow holes and other irregularities. All sharp edges shall be ground smooth.

All seams shall be sealed with RTV sealant or equivalent material on the interior of the cabinet.

All cabinets shall be supplied with two removable shelves manufactured from 5052H32 aluminum. Shelf shall be a minimum of 10 inches deep.

One set of vertical "C" channels shall be mounted on each interior wall of the cabinet for the purpose of mounting the cabinet components. The channels shall accommodate spring mounted nuts or studs. All mounting rails shall extend to within 7 inches of the top and bottom of the cabinets.

The main door and police door-in-door shall close against a weatherproof and dustproof, closed cell neoprene gasket seal. The gasket material for the main door shall be a minimum of 0.188 inches thick by 1.00 inches wide. The gasket material for the police door shall be a minimum of 0.188 inches thick by 0.500 inches wide. The gaskets shall be permanently bonded to the cabinet.

The lower section of the cabinet shall be equipped with a louvered air entrance. The air inlet shall be large enough to allow sufficient airflow per the rated fan capacity. Louvers must satisfy the NEMA rod entry test for 3R ventilated enclosures. A noncorrosive, vermin- and insect-proof, removable air filter shall be secured to the air entrance. The filter shall fit snugly against the cabinet door wall.

The roof of the cabinet shall incorporate an exhaust plenum with a vent screen. Perforations in the vent screen shall not exceed 0.125 inches in diameter.

The main door shall be equipped with a three-point latching mechanism.

The handle on the main door shall utilize a shank of stainless steel 3/4 inch minimum diameter. The handle shall include a hasp for the attachment of an optional padlock. The cabinet door handle shall rotate clockwise to open. The lock assembly shall be positioned so that the handle shall not cause any interference with the key when opening the cabinet door.

The main door hinge shall be a one-piece, continuous piano hinge with a stainless steel pin running the entire length of the door. The hinge shall be attached in such a manner that no rivets or bolts are exposed.

The main door shall include a mechanism capable of holding the door open at approximately 90, 120, and 180 degrees under windy conditions.

Each cabinet door shall be provided with a high quality, heavy duty tumbler-type lock. Two keys for each tumbler lock shall be provided for each cabinet. All locks for the project shall be keyed identically in the key pattern identified by the City of Council Bluffs. Keys shall be given to the City of Council Bluffs. Do not attach keys to the exterior of the cabinet at any time during storage or installation.

In addition to the main door of the controller cabinet, there shall be an auxiliary police door provided in the main door provided with a strong lock and two keys of different design than that of the main door of the cabinet. The panel behind the auxiliary police door shall contain a switch to change from normal function to flashing operation. The controller shall remain in full operation during flash operation. Provide a signal on-off switch to interrupt power to the signal heads only and continue controller operation.

All base mounted cabinets shall be supplied with anchor bolts to properly secure the cabinet to its base. The cabinet flange for securing the anchor bolts shall not protrude outward from the bottom of the cabinet. When a size 5 cabinet is furnished, two anchor bolts shall be provided. Size 6 and 7 cabinets shall be provided with four anchor bolts. Each cabinet shall be of sufficient size to accommodate all equipment.

At a minimum, the minimal cabinet sizes are as follows:

- Size 4 cabinets – 51 inches H by 24 inches W by 16 inches D
- Size 5 (M) cabinets – 51 inches H by 30 inches W by 16 inches D
- Size 6 (P) cabinets – 56 inches H by 44 inches W by 24 inches D
- Size 7 (R) cabinets – 77 inches H by 44 inches W by 24 inches D

The size 6 (P) cabinet is to be used unless a specific cabinet size is called out on the plans.

Note: Height measured at front of cabinet.

The cabinet shall be a base mounted unit with a concrete foundation as per the plan details. A level concrete pad with a broom finish and dimensions of 36 inches by width of cabinet by 5 inches shall be installed adjacent to the cabinet base on the side of the cabinet door. A 1/2 inch expansion material shall be installed between the cabinet base and the concrete pad.

TERMINALS AND FACILITIES/MAIN PANEL DESIGN AND CONSTRUCTION:
The main panel shall be constructed from 5052-H32 brushed aluminum of 0.125 inch minimum thickness and formed so as to eliminate any flexing when plug-in components are installed.

All 4, 8, 12 and 16 position main panels shall be hinged at the bottom to allow easy access to all wiring on the rear of the panel. It shall not be necessary to remove any shelf-mounted equipment to hinge down the main panel.

The main panel shall be fully wired in the following configurations:

- Type 1 Configuration - Four load switch sockets, two flash transfer relay sockets, one flasher socket and two main panel Bus Interface Unit (BIU) rack positions.
- Type 2 Configuration - Eight load switch sockets, four flash transfer relay sockets, one flasher socket and two main panel BIU rack positions.
- Type 3 Configuration - Twelve load switch sockets, six flash transfer relay sockets, one flasher socket and two main panel BIU rack slots.
- Type 4 Configuration - Sixteen load switch sockets, eight flash transfer relay sockets, one flasher socket and two main panel BIU rack slots.

All load switch and flash transfer relay socket reference designators shall be silkscreen labeled on the front and rear of the main panel to match drawing designations.

Up to eight-load switch sockets may be positioned horizontally or stacked in two rows on the main panel. Main panels requiring more than six load switch sockets shall be mounted in two horizontal rows.

All load switches shall be supported by a bracket extending at least three inches from the main panel.

Rack style mounting shall be provided to accommodate the required BIUs per the configuration listed in section 3.3 above. A dual-row, 64-pin female DIN 41612 Type B connector shall be provided for each BIU rack position. Card guides shall be provided for both edges of the BIU.

Terminal and facilities BIU mounting shall be an integral part of the main panel. Detector rack BIU mounting shall be an integral part of the shelf-mounted detector rack.

All BIU rack connectors shall have prewired address pins corresponding to the requirements of the TS2 specification. The address pins shall control the BIU mode of operation. BIUs shall be capable of being interchanged with no additional programming.

All main panels shall have all field wires contained within one row of horizontally mounted terminal blocks.

All field output circuits shall be terminated on an unfused compression type terminal block with a minimum rating of 10 amps.

All field input/output (I/O) terminals shall be identified by permanent alphanumeric labels. All labels shall use standard nomenclature per the NEMA TS2 specification.

All field flash sequence programming shall be accomplished at the field terminals with the use of a screwdriver only.

Field terminal blocks shall be wired to use three positions per vehicle or overlap phase (green, yellow, red).

The main panel shall contain a flasher socket (silk screen labeled) capable of operating a 15-amp, 2-pole, NEMA solid-state flasher. The flasher shall be supported by a bracket that extends at least three inches from the back panel.

One RC network shall be wired in parallel with each flash transfer relay coil.

All logic-level, NEMA-controller and Malfunction Management Unit input and output terminations on the main panel shall be permanently labeled. Cabinet prints shall identify the function of each terminal position.

Terminal blocks for DC signal interfacing shall have a number 6-32 x 7/32 inch screw as minimum. Functions to be terminated shall be as specified in the listing of Input/Output Terminals in the TS2-1992 Standard document (Section 5).

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

- Green/Walk load switch output brown wire 16 gauge
- Yellow load switch output yellow wire 16 gauge
- Red/Don't Walk load switch output red wire 16 gauge
- MMU (other than AC power) blue wire 22 gauge
- Controller I/O blue wire 22 gauge
- AC Line (power panel to main panel) black wire *
- AC Line (main panel) black wire *
- AC Neutral (power panel to main panel) white wire *
- AC Neutral (main panel) white wire *
- Earth ground green wire *

Gauge varies with power panel/main panel set

All wiring, No. 14 AWG and smaller, shall conform to MIL-W-16878/1, type B/N, 600 V, 19-strand tinned copper. The wire shall have a minimum of 0.010 inch thick PVC insulation with clear nylon jacket and rated to 221°F. All No. 12 AWG and larger wire shall have UL listed THHN/THWN 194°F, 600V, 0.020 inch thick PVC insulation and clear nylon jacketed.

All controller and Malfunction Management Unit cables shall be of sufficient length to allow the units to be placed on either shelf or the outside top of the cabinet in the operating mode.

Connecting cables shall be sleeved in a braided nylon mesh. The use of exposed tie-wraps or interwoven cables is unacceptable.

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

All wiring shall be neat in appearance. All cabinet wiring shall be continuous from its point of origin to its termination point. Butt type connections/splices are not acceptable.

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

The grounding system in the cabinet shall be divided into three separate circuits (AC Neutral, Earth Ground, and Logic Ground). These ground circuits shall be connected together at a single point as outlined in the NEMA TS2 Standard.

All pedestrian pushbutton inputs from the field to the controller shall be optoisolated through the BIU and operate at 12 VAC.

All wire (size No. 16 AWG or smaller) at solder joints shall be hooked or looped around the eyelet or terminal block post prior to soldering to ensure circuit integrity. Lap joint soldering is not acceptable.

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

POWER PANEL DESIGN AND CONSTRUCTION:
The power panel shall consist of a separate module, securely fastened to the right side wall of the cabinet. The power panel shall be wired to provide the necessary power to the cabinet, controller, Malfunction Management Unit, cabinet power supply and auxiliary equipment. It shall be manufactured from 0.090 inch, 5052-H32 aluminum.

The power panel shall house the following components:

- A 50-amp main breaker for 12 or 16 position cabinets or a 30-amp breaker for 4 or 8 position cabinets. This breaker shall supply power to the controller, MMU, signals, cabinet power supply and auxiliary panels. Breakers shall be thermal magnetic type, U.L. listed, with a minimum of 10,000 amp interrupting capacity.
- A 15-amp auxiliary breaker. This breaker shall supply power to the fan, light and GFI outlet.
- A 50 amp, 125 VAC radio interference line filter.
- A normally open, 60 amp, mercury contactor for 12 or 16 position or a 35 amp. contactor for 4 or 8 position facilities.
- A 13-position neutral bus bar capable of connecting three No. 12 AWG wires per position.

AUXILIARY CABINET EQUIPMENT:
The cabinet shall be provided with a thermostatically controlled (adjustable between 80°F and 150°F) ventilation fan in the top of the cabinet plenum. The fan shall be a ball bearing type fan and shall be capable of drawing a minimum of 100 cubic feet of air per minute.

An LED light panel shall be mounted on the inside top of the cabinet. The LED light panel shall be 15-17W and be wired into the cabinet power circuit and not obtain power from the convenience outlet. The LED light panel shall be wired to either a ON/OFF switch mounted on the rear cover of the police plan or to a door activated switch mounted near the top of the door.

A sealable print pouch shall be mounted to the door of the cabinet. The pouch shall be of sufficient size to accommodate one complete set of cabinet prints.

Two sets of complete and accurate cabinet drawings shall be supplied with each cabinet.

One set of manuals for the controller, Malfunction Management Unit and vehicle detector amplifiers shall be supplied with each cabinet.

A heavy-duty clear plastic envelope shall be provided, securely attached to the inside wall of the cabinet or cabinet door, for stowing cabinet wiring diagrams and equipment manuals. Minimum dimensions shall be 9 inches wide by 12 inches deep. The envelope will contain information that will identify a general

outline of the intersection, provide directional orientation, intersection phasing, signal head identification, and identify the loop numbering. The drawing shall be done neatly by hand drafting or in a computer aided drafting format. All lines, symbols, and lettering shall be highly visible using a black foreground on either a white or yellow background. The drawing need not be drawn to scale. A legend shall be provided for all symbols used within the drawing.

VEHICLE DETECTION:
A vehicle detector amplifier rack shall be provided in each cabinet. Detector racks shall be available in two configurations.

- Configuration #1 – Shall support up to eight channels of loop detection and one BIU.
- Configuration #2 – Shall support up to 16 channels of loop detection and one BIU.

Each cabinet shall contain detector interface panels for the purpose of connecting field loops and vehicle detector amplifiers. The panels shall be manufactured from 0.090 inch minimum thickness 5052-H32 aluminum.

One 8-position interface panel shall be provided for an 8-channel rack cabinet and one 16-position interface panel shall be provided for a 16-channel rack cabinet. The interface panel shall be secured to the left sidewall of the cabinet.

Each interface panel shall allow for the connection of eight or sixteen independent field loops. A ground bus terminal shall be provided between each loop pair terminals to provide a termination for the loop lead-in cable ground wire.

Lightning protection device mounting holes shall be provided to accommodate an Edco SRA-16C, or Edco SRA-6, or Edco LCA-6, or a varistor lightning protection device. Lightning protection devices shall not be provided unless specifically called for in the special provisions of this specification.

A cable consisting of No. 22 AWG twisted pair wires (red and orange) shall be provided to enable connection to and from the panel to a detector rack.

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

Detectors shall utilize extension and delay timings. All card slots shall be filled with detectors. A dual output detector card shall be used when dual detector outputs are required on the plans.

Each detector rack shall be powered by the cabinet power supply (refer to section 9.6 of this specification).

CABINET TEST SWITCHES AND POLICE PANEL:
A test switch panel shall be mounted on the inside of the main door. The test switch panel shall provide as a minimum the following:

AUTO/FLASH SWITCH:
When in the flash position, power shall be maintained to the controller and the intersection shall be placed in flash. The controller shall not be stop timed when in flash. If required by the plans and specifications, an optional RC network shall be provided to give the controller an external start pulse when switch is returned to the auto position. This will force the controller to initiate the start up sequence when exiting flash.

STOP TIME SWITCH:
When applied, the controller shall be stop timed in the current interval.

CONTROL EQUIPMENT POWER ON/OFF:
This switch shall control the controller, MMU, and cabinet power supply AC power.

Momentary test pushbuttons for all vehicle and pedestrian inputs to the controller are not required. The TS2 controller to be provided with the cabinet assembly shall provide vehicular and pedestrian call inputs from its keyboard while in the standard status display.

The police door switch panel shall contain the following:

SIGNALS ON/OFF SWITCH:
In the OFF position, power shall be removed from signal heads in the intersection. The controller shall continue to operate. When in the OFF position, the MMU shall not conflict or require reset.

AUTO/FLASH SWITCH:
In the flash position, power shall not be removed from the controller and stop time shall be applied. If required by the plans and specifications, an optional RC network shall be provided to give the controller an external start pulse when switch is returned to the auto position. This will force the controller to initiate the start up sequence when exiting flash.

AUTO/MANUAL SWITCH:
Cabinet wiring shall include provisions for an AUTO/MANUAL switch and a momentary pushbutton or hand cord. The AUTO/MANUAL switch and pushbutton or hand cord shall not be provided unless it is called for in the special provisions of this specification.

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

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

All switch functions must be permanently and clearly labeled.

All wire routed to the police door-in-door and test switch pushbutton panel shall be adequately protected against damage from repetitive opening and closing of the main door.

CONTROLLER TELEMETRY INTERFACE PANEL:
A telemetry interface harness and interface panel shall be supplied with each cabinet assembly.

The harness shall be a minimum of 6 feet long and shall consist of two twisted pairs, No. 22 AWG wire, terminated to a 9-pin "D" type connector at one end. The pin out of the 9-pin connector shall be in exact accordance with the NEMA TS2 Standard. The opposite end of the harness shall be terminated on a 10-position lightning protection socket base.

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

The following signals shall be accessible from the telemetry interface panel:

- Local controller command lines 1 & 2.
- Local controller readback lines 1 & 2.
- Master controller command lines 1 & 2.
- Master controller readback lines 1 & 2.
- Earth grounds.

A socket mounted communication line transient protection device shall be supplied with the telemetry interface panel. The transient protection device shall be wired in series with the telemetry communication circuit.

AUXILIARY DEVICES:

LOAD SWITCHES:

Load switches shall be solid state and shall conform to the requirements of Section 6.2 of the NEMA TS2 Standard.

Signal load switches shall have a minimum rating of 10 amperes at 120 VAC for an incandescent lamp load.

The front of the load switch shall be provided with three indicators to show the input signal from the controller to the load switch.

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

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

FLASHERS:

The flasher shall be solid state and shall conform to the requirements of section 6.3 of the NEMA TS2 Standard. Flashing of field circuits for the purpose of intersection flash shall be accomplished by a separate flasher.

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

FLASH TRANSFER RELAYS:

All flash transfer relays shall meet the requirements of Section 6.4 of the NEMA TS2 Standard.

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

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

MALFUNCTION MANAGEMENT UNITS:

Each cabinet assembly shall be supplied with one Malfunction Management Unit (MMU). The MMU shall meet or exceed all requirements and specifications of the latest NEMA TS2 Standard.

BUS INTERFACE UNITS:

All Bus Interface Units (BIUs) shall meet the requirements of Section 8 of the NEMA TS2 Standard.

The full complement of BIUs shall be supplied with each cabinet to allow for maximum phase and function utilization for which the cabinet is designed.

Each Bus Interface Unit shall include power on and transmit indicators. All indicators shall be LEDs.

CABINET POWER SUPPLY:

The cabinet power supply shall meet the requirements of Section 5.3.5 of the NEMA TS2 Standard.

The cabinet power supply shall provide LED indicators for the 12 VDC, 12 VAC, and 24 VDC outputs.

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

One cabinet power supply shall be supplied with each cabinet assembly.

ETHERNET SWITCH:
Each cabinet shall be equipped with an 8 port managed Ethernet switch. Contractor shall supply 10/100 based Ethernet switches required for the communications of the Traffic Signal/ITS System. The switch will have six 10/100 Ethernet ports and two Single Mode Fiber ports. Field hardened NEMA TS-2 (traffic control equipment), fully managed network switches shall be installed within traffic signal cabinets. The Ethernet switch shall be attached to a side panel of the cabinet. Patch cables to provide functional connection of the Ethernet switch to the Fiber Optic distribution panel and to the signal controller shall be provided.

The Ethernet field switch located in each cabinet shall comply with the Operating Voltage, Operating Frequency, Power Interruption, Temperature and Humidity, Power Service Transients, Vibration and Shock requirements outlined in NEMA TS 2 Environmental Requirements. The unit shall not exceed 10 inches in height, width or depth. Ethernet switch specifications are as follows:

INPUT POWER:

- The Field ITS Ethernet Switches shall be powered via 24 VDC input or may be optionally powered via 115 VAC direct input.
- The Field ITS Ethernet Switches shall include all power cables and power adapters (transformer / power packs) needed to connect to a 5-15R style power receptacle. When power adapters have an integrated power connector, stress relief clamps shall be provided when necessary to secure the connection.
- If an external Power supply or pack is used, it shall meet NEMA TS 2 environmental requirements.
- The unit shall not exceed 100 watts total power consumption.

NETWORK MANDATORY SPECIFICATIONS:
The Field ITS Ethernet Switch shall meet the below Network standards, where applicable.

- IEEE 802.3: 10BASE-TX specification
- IEEE 802.3u: 100BASE-TX specification
- IEEE 802.3x: Flow Control

AVAILABILITY:

- IEEE 802.1d: Spanning-Tree Protocol supports redundant connection and loop free network.
- IEEE 802.1w: Rapid Spanning-Tree Protocol (RSPT) provides rapid convergence of the spanning tree, independent of spanning tree timers.
- IEEE 802.1q: Virtual Local Area Network (VLAN) allows the segregation of a physical network into separate logical network with independent broadcast domains. Non-native VLAN 1 management capability is required.
- IGMP Snooping (v1 & v2): IGMP Snooping and multicast pruning limits traffic to those ports that need to participate in the multicast. The switch shall support IGMP snooping on all supported VLANs.

SECURITY:

- Multi-Level password access security: Multi-level password access security via console, Web, and telnet. The minimum requirement is two levels: read only and read-write.
- SSH/SSL – Extend capability of password protection to add 128-bit encryption of passwords and data
- SFTP – Secure File Transfer Protocol using SSH encription
- Port security:
    - Enable/Disable ports
    - MAC Based Port security secures the access to a port based on the MAC address of a user's device.
    - 802.1x Port Based Network Access Control – the ability to lock down ports to allow only

authorized users access to communicate via that port.
    - 802.1Q VLAN – Segregate traffic between predefined ports on switches
- All Ethernet Field Switches shall be UL 1950 or 60950 certified.

MANAGEMENT:
- Central manageable: Capable to be upgraded (firmware/software configured and monitored by central management software.
- SNMPv3: encrypted authentication access security and data encryption (CBC-DES with 56-bit encryption key)

CLI: LOCAL CONSOLE PORT ACCESS TO COMMAND LINE INTERFACE:
- Telnet: Telnet protocol supports remote access to the switch.
- TFTP: Trivial File Transfer Protocol that can reduce the cost of administering firmware upgrades by downloading from a centralized location.
- HTTP: Access switch via Web Browser.
- Port mirroring: To duplicate all traffic on a port or a VLAN to a designed mirror port. This is very useful for troubleshooting.
- RMON: Remote Monitoring.
- NTP: Network Timing Protocol provides an accurate and consistent timestamp to all switches within the intranet.
- LED indicator Multifunction LEDs per port for port status. Power Supply indicator. Major & minor alarm indicators.
- Event Logging: Capable of logging different severity levels of system error locally &/or remotely to a central management station.

CONNECTORS & CABLING:
- 10/100BASE-TX port: RJ-45 Connector; two or four pairs Cat5 UTP cabling.
- 100BASE-FX (SMF) port: LC, MT-RJ, SC connectors, 9-10/125 micron single mode fiber-optic cabling.
- Management Console port: DB9 to DB9 or RJ-45 to DB9 console cable.

FIBER PORT SPECIFICATIONS:
- 100BASE-FX (SMF): interoperable with 1300 nm and 15km &/or longer distance.

CONFIGURATION:
The Ethernet Field Switch Units shall provide for the storage of the configuration in a non-volatile manner by one or more of the following methods:
- The configuration is automatically stored within the unit during a configuration session
- The configuration is explicitly stored within the unit during a configuration session

The configuration capability shall provide for all of the following:
- Be configurable locally via console port.
- Be modifiable/configurable via telnet or HTTP for an individual switch remotely.
- Be automatically modifiable/configurable via TFTP or a central management system for an individual switch and groups of switches remotely.

SELF-RECOVERY:
At startup and after a power disruption, the unit shall reach operational state within 5 minutes of the application/restoration of normal input power. Within this time, the configuration of the unit will be automatically set to one of the following:
- The configuration of the unit prior to the power disruption;
- The last configuration explicitly stored within the unit during a configuration session.

FCC REGULATORY:
All Ethernet Field Switches shall be compliant with FCC, Part 15 (Class A).

MOUNTING REQUIREMENTS:
The switch should be capable of DIN Rail mounting (Standard EIA 19 inch width rack) or ”C” channel rail mounting in a Traffic Signal Controller Cabinet (NEMA TS-2 Cabinet – Type 1).

REPAIR AND SUPPORT SERVICES:

- The vendor shall provide telephone customer support as required during normal business hours, at no cost during the warranty period.
- The vendor shall stock the necessary replacement products to maintain the operability of the system for a period of at least 5 years from the date of delivery.

PRODUCT WARRANTY:

- The Field ITS Ethernet Switch and Optional Ethernet Products offered by the Offeror and furnished software shall be warranted by the manufacturer for a minimum of 5 years from the date of delivery.
- The period of warranty coverage shall not be less than the manufacturers usual and customary warranty period.
- The Agency, or the manufacturer’s representative, may make minor warranty repairs with the consent of the manufacturer. The manufacturer will make all other warranty repairs. The Offeror/vendor will bear all costs, including labor, parts, and shipping charges.
- All revisions and updates to the furnished software or firmware shall be provided during the warranty period at no additional cost. With consent of the manufacturer, the Agency shall assume responsibility for installation of updates to systems that have been in use for more than 30 days.
- The Field ITS Ethernet Switches and accompanying software offered by the Offeror found to be defective during the warranty period shall be replaced or repaired free of charge by the manufacturer. The replacement or repair of defective equipment or accompanying software shall occur within 14 calendar days of notification by the City. Notification by the City will be in the form of an email or official letter.

TESTING:
Each controller and cabinet assembly shall be tested as a complete entity under signal load for a minimum of 24 hours.

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

WARRANTY:
The controller and Malfunction Management Unit shall be warranted by the manufacturer against mechanical and electrical defects for a period of 1 year. The manufacturer’s warranty shall be supplied in writing with each cabinet and controller. Second party extended warranties are not acceptable.

The cabinet assembly and all other components shall be warranted for a period of one year.

Any defects shall be corrected by the manufacturer or supplier at no cost to the owner.

D. ELECTRICAL DESIGN

The distribution of the 117 VAC throughout the cabinet shall not occur until the AC+ has first passed through the power protection devices. The cabinet shall be provided with power protection devices, which include the main AC+ power circuit breakers, radio interference suppressers, and lightning and surge protectors. The cabinet shall be provided with surge protection and radio interference (RFI) filters and lightning protection. These functions may be combined into one or more devices. Combining of devices

shall be supported by manufacturer's printed literature stating specific compliance to standard industry levels.

Surge protectors shall provide a general cabinet protection as a parallel device. Additional protection shall be provided to all electronic devices such as the traffic Controller and conflict monitor via a series surge protector working in conjunction with the general cabinet protection.

Surge protection, RFI's, etc. shall be rated at the ampacity of the breaker protection. Main cabinet circuit breakers for shall be a minimum of 50 amps. A minimum of three circuit breakers shall be provided. The main cabinet breaker shall service all Controller and terminal facilities. The auxiliary breaker shall provide service to the cabinet detectors, masters, and other electronic equipment. The service breaker shall provide service to the fan, thermostat, cabinet heater, etc.

All cabinets housing a Master Unit, video detection equipment or radio transceivers shall be provided with a cabinet heater. The cabinet heater shall be mounted on a winter panel suitable of mounting in place of the cabinet filter assembly. The heater shall be rated at 250 watts and be connected by a twist plug into a receptacle mounted on the bottom right front side panel of the cabinet. The heater circuit shall be provided with a thermostat separate from the cabinet fan thermostat and be settable between 32°F and -30°F. The cabinet fan thermostat shall be settable between 75°F and 150°F. The heater shall have a wire mesh shield cover attached to the metal weatherproof cover to block the fan vent assembly. A three-position switch shall be provided to select power to the fan, the heater or select neither. Wiring to the heater shall be stranded copper wire having 392°F insulation and be connected using non-insulated solderless terminals.

Duplex outlets, which are provided for equipment such as modems and other low current auxiliary equipment, shall also be provided with series-parallel lightning protection. Such outlets will be clearly identified to denote that they are specifically to be used for low current auxiliary electronic equipment only. The surge protector shall be capable of a peak current of 20,000 amps in an 8 by 20 microsecond wave shape; have a life test with a maximum of a 5% change; have a clamp voltage not to exceed 280 volts @ 20 KA; have a response time to insure that the maximum voltage never exceeds 280 volts; is rated for 10 amps continuous service; and can operate from -40°F to +185°F.

Load switches and other high current devices shall require only parallel lightning protection devices. An MOV shall be installed on the radio interference suppressor between both the AC+ line to ground and the AC+ load to ground. The protection devices shall be mounted on a panel that is securely fastened to an interior wall of the cabinet.

Each signalized location shall utilize a standard 2 pole, weather tight circuit breaker type disconnect. The unit shall be rated a minimum of 60 amps and grounded as per NEC standards.

The disconnect shall be electrically located after the battery backup system (BBS).

The controller shall contain a connector enabling outgoing and incoming electrical circuits to be connected or disconnected easily without the necessity of installing or removing individual wires.

The connector may be a multiple pin jack; a spring connected mounting, or approved equivalent mounting.

In the event of a power interruption, the controller shall be capable of automatic reorientation upon power resumption and shall require no manual initiation or switching.

Electrical connections from the controller and auxiliary devices to outgoing and incoming circuits shall be made in such 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. This may be accomplished by means of a multiple plug; a spring connected mounting or approved equivalent arrangement.

All cabinet wiring shall be neatly trained throughout the cabinet and attached to the interior panels using nonconductive clamps or tie-wraps. Bundles of cables shall be laced or tied 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.

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.

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

An AC+ convenience outlet with a 3-wire grounding type receptacle shall be provided and be easily accessible. This receptacle and the incandescent lamp shall be separately fused from the main AC+ circuit breaker. The outlet shall be provided with ground fault protection.

The cabinet duct fan shall be fused separately and wired after the main AC+ circuit breaker.

The outgoing signal circuits shall be of the same polarity as the line (+) side of the power service.

The incoming signal indication conductors shall be common and of the same polarity as the grounded (-) side of the power service. The neutral (-) side of the power service shall be connected to the cabinet in an approved manner to a copper ground bus located on the panel with the main AC+ circuit breaker. The cabinet shall, in turn, be connected to an earth ground through a ground rod system located outside the controller cabinet. (See grounding sections for details.) No ground rods shall be installed inside the controller cabinet.

E. TRAFFIC SIGNAL BATTERY BACKUP SYSTEM (BBS)

This section sets forth requirements for a system to provide back-up power to fully operate a traffic signal when normal line voltage is interrupted and to maintain a useable output voltage when line voltage is outside normal levels.

MATERIALS:
Furnish, assemble, fabricate, or install new corrosion resistant materials in accordance with specifications. Supply a “rack mounted” UPS unit, including a front panel with indicators and control switches.

FUNCTIONAL REQUIREMENTS:
This specification is for establishing the minimum requirements for a complete emergency battery backup system for use with Light Emitting Diode Traffic Signal Modules at traffic signals with NEMA, 170 or 2070 cabinets.

The Battery Backup System (BBS) shall include, but not be limited to the following:

- Inverter/Charger, Batteries, a separate automatic and manually operated Bypass Switch, and all necessary hardware and interconnect wiring.
- The BBS shall be capable of providing power for both the full normal operation of a traffic signal with all LED displays (all colors: red, yellow, green and pedestrian heads), and flashing mode operation with all LED displays.
- The BBS shall be designed for outdoor applications.

ENCLOSURE CONSTRUCTION:
ENCLOSURE:
The BBS Enclosure shall be capable of being either a Side Mount or Ground Mount installation.

The enclosure will house the batteries, UPS and bypass switches. The cabinet must meet the requirements for NEMA 3R enclosures. The housing must have the dimensions so that it may easily be

attached to the side of an M, P, or 332 Type traffic signal cabinet. Dimensions of the enclosure shall not exceed 50 inches H by 20 inches W by 17 inches D. The UPS enclosure must not interfere with the opening of the traffic cabinet door. The complete enclosure and door must be made from 0.125 inch thick aluminum. All external seams must be continuously welded. The door opening must have a double flange for weather sealing purposes.

DOOR:
The cabinet must have a door to provide access to the complete cabinet interior. The door must be mounted on a continuous piano hinge. The key lock must be a Corbin cylinder lock with a #2 key. A continuous neoprene gasket must be used to weatherproof the enclosure when the door is closed.

FINISH:
The entire enclosure must be natural aluminum.

VENTILATION:
Vents and a thermostatically controlled exhaust fan shall be installed in the cabinet.

BATTERY SYSTEM:
Individual batteries shall be easily replaced and commercially available off the shelf. Batteries shall be maintenance free, type AGM/VRLA (Absorbed Glass Mat/Valve Regulated Lead Acid).

The batteries must be designed for stand-by applications.

Batteries shall be certified by the manufacturer to operate over a temperature range of –13°F to +165°F.

Batteries shall have a minimum Manufacturer's Warranty of 2 Years Full Replacement from date of delivery. The warranty shall cover any battery that does not meet 80% of its original reserve capability during the warranty period.

BBS UNIT:
The BBS shall provide a minimum two hours of full run-time operation with an additional four hours minimum of Red Flash operation at an LED only traffic signal with a maximum 800 W active output load. The inverter, when on batteries, shall operate with a minimum efficiency of 84% with a load ranging from 25% to 90% of the BBS total output rating. The BBS shall operate at 97% or higher when operating under normal condition (utility power is available).

The maximum transfer time allowed, from disruption of normal utility line voltage to stabilized inverter line voltage from batteries, shall be 5 milliseconds. 5 milliseconds maximum allowable transfer time shall also apply when switching from inverter line voltage to utility line voltage.

The BBS shall include a rack mounted Fail Safe Automatic/Manual Bypass Switch for bypassing the UPS for maintenance. The FS-ATS bypass switch will be a 3-stage configuration, UPS Normal mode, bypass UPS on and bypass UPS off. The FS-ATS Bypass Switch shall mount in a rack inside of the BBS side mount enclosure.

The BBS shall provide 6 sets of programmable output contacts. These shall include:

- One output to indicate the system is "on battery".
- One output to indicate a programmable low battery condition.
- One output that energizes after a programmable period after the unit switches to battery operation.
- An indication of a fault or alarm condition.
- The BBS will provide a visual indication for each output when activated.
- The BBS shall provide inputs to turn the BBS off and to start the self-test.

Operating temperature for both the inverter/charger, and manual bypass switch shall be –30°F to +165°F.

The Fail Safe ATS Bypass Switch shall be rated at 240VAC/30 amps, minimum.

The BBS shall use a temperature compensated charging system. The BBS shall employ a charging system that balances the charge across all the batteries.

BBS shall bypass the utility line power whenever the utility line voltage is outside of the following voltage range: 85VAC to 175VAC (± 2VAC). During a utility input from 85 VAC to 175 VAC the UPS shall maintain a full load output of 108 VAC to 131 VAC at 60Hz.

When utilizing battery power, the BBS output voltage shall be between 110 VAC and 128 VAC, pure sine wave output, ≤ 3% THD, 60Hz ± 3Hz.

BBS shall be compatible with NEMA, 170 or 2170 Controllers, and cabinet components for full time operation. All loads to the maximum rating of the BBS shall be powered through the BBS system to utilize the UPS internal over/under voltage regulation.

BBS shall be equipped to prevent a malfunction feedback to the cabinet or from feeding back to the utility service. The UPS module must be UL approved and labeled.

In the event of inverter/charger failure, battery failure or complete battery discharge, the Fail Safe Transfer Switch shall revert to the NC (and de-energized) state, where utility line power or generator power, if available, is connected to the cabinet.

Recharge time for the battery, from “protective low-cutoff” to 90% or more of full battery charge capacity, shall not exceed 8 hours, unless limited by the Temperature Regulated charger due to excessive battery heat.

The battery charger will be compatible with the specified batteries.

The BBS shall have lightning and surge protection compliant with IEEE/ANSI C.62.41.

The BBS shall be equipped with an integral system to prevent battery from destructive discharge and overcharge.

MAINTENANCE, DISPLAYS, CONTROLS AND DIAGNOSTICS:
The BBS shall include a display and /or meter to indicate current battery charge status and conditions. The BBS and batteries shall be easily replaced with all needed hardware and shall not require any special tools for installation.

The BBS shall display via a front panel indicator the number of times the BBS was activated and the total number of hours the unit has operated on battery power. The status display shall show the UPS mode, Alarm status, Input and output voltages, Output current, Battery voltage, battery charger current and last event.

The BBS shall include two separate communication ports, an RJ-45, 10/100 Ethernet port and a DB-9, RS 232 serial port. All programming and monitoring functions shall be available through either port.

The BBS shall include software for programming and monitoring the BBS. The software shall be capable of being used on a PC with all current Microsoft operating systems.

Manufacturer shall include a set of operation manuals and wiring diagrams of the BBS with each BBS.

MATERIALS WARRANTY:
The manufacturer shall provide a 2 year factory-repair warranty for parts and labor on the BBS.

Batteries shall be warranted by the manufacturer for full replacement for a minimum 2 years from date of delivery. A battery shall be considered bad when it cannot deliver 80% of its original capability within the stated warranty period.

Warranty shall be included in the total price of the BBS.

F. ELECTRICAL SERVICE PEDESTAL

When a ground mounted service enclosure is specified in the plans, the following shall apply.

SERVICE ENCLOSURE:
The service enclosure shall meet or exceed the requirements of UL 508, Industrial Control Equipment. Fabricate the exterior of the service enclosure using 1/8 inch aluminum. Fabricate the interior of the service enclosure using 14 gauge, cold-rolled steel. Paint the interior of the service enclosure white. The interior dimensions of the service enclosure shall be 12 inches wide by 43 inches high by 7 1/2 inches deep. The service enclosure shall have continuously welded seams, a full-length deadfront with stainless steel hinge and a pull section with a removable step.

The service enclosure shall have a fully framed, side-hinged, swaged outer door, flush fitted with top drip lip and closed cell neoprene flange-compressed gaskets. The service enclosure shall have a hinged deadfront with a 1/4 turn latch and knurled knobs. Hinge the deadfront door on the same side as the exterior door. The deadfront door shall open a minimum of 100 degrees.

Mount a removable backpan on four welded 1/4 inch studs. The service enclosure shall be completely pre-wired in the factory. Bolt-on or plug-in circuit breakers are not acceptable.

WIRING SCHEMATICS:
Produce wiring schematics using drafting software. Include all external equipment and connections in accordance with NEMA IIB. Enclose as-built factory drawings in clear plastic.

Store drawings inside the outer door using welded hooks.

Service conductors shall meet the requirements of Section 230 of the National Electric Code (NEC).

G. EMERGENCY VEHICLE TRAFFIC SIGNAL PRIORITY CONTROL SYSTEM

This is a system that employs optical communication to identify the presence of designated priority vehicles and cause the traffic signal controller to advance to and/or hold a desired traffic signal display.

The Contractor shall install the emergency vehicle traffic signal priority control system units to identify the presence of designated priority or probe vehicles. In priority vehicle mode, the data-encoded communication will request the traffic signal controller to advance to and/or hold a desired traffic signal display selected from phases normally available. In probe vehicle mode, no traffic signal priority is requested – only a record of the probe vehicle's presence is generated.

The required priority control, data-encoded, infrared communications system will be comprised of five basic matched components: data-encoded emitter, infrared detector, detector cable, phase selector and system software .To ensure system integrity, operation and compatibility; all components will be from the same manufacturer. Contractor shall install the Global Traffic Technologies Opticom brand emergency vehicle traffic signal priority control system, (Preempt System) in all traffic signal systems.

Emergency vehicle traffic signal detector systems shall consist of a receiver and associated wire components. The receivers shall be mounted at or near the intersections to be controlled. The system shall be supplied with all of the equipment required for the operation, including but not limited to:

OPTICOM DETECTION:
Each optical detection / discriminator assembly shall consist of one or more detectors, connecting cable and a discriminator module. Each such assembly when used with standard emitters shall have a range of at least 1800 feet. Standard emitters for both classes of signals shall be available from the manufacturer of the system.

The emergency vehicle preemption (EVPE) detector shall be mounted on the mast arm using an astro bracket with threaded nipples and lock washers.

The emergency vehicle preemption (EVPE) detector cable shall be a Global Traffic Technologies Opticom detector cable, Model 738 (or approved equal).

Field terminal T-9 in the cabinet shall be fully configured for proper preemption operation.

All internal circuitry shall be solid-state and electric power shall be provided by the respective discriminator module.

OPTICAL DETECTOR:
Each optical detector, Model 722, shall be a weatherproof unit capable of being easily mounted on a mast arm. The housing shall have at least one opening threaded for 3/4 inch conduit, through which all wiring shall enter. Each detector shall weigh not more than 2 pounds and shall present a maximum wind load area of 36 square inches. Each detector shall be capable of receiving optical energy from either one of both of two axially opposed directions.

The reception angle shall be a maximum of ± 6 degrees (12 degrees total included angle) measured in the horizontal plane about the center axis of the light-sensing element. The reception angle in the vertical plane measured about the center axis of the light-sensing element shall be a maximum of 4 degrees above and 8 degrees below that center axis. Measurements are to be taken with emitter assembly at near maximum range.

PHASE SELECTOR:
The phase selector, Model 764, designed to be installed in the traffic controller cabinet, will accommodate data-encoded signals and is intended for use directly with numerous controllers. These include California/New York Type 170 controllers with compatible software, NEMA controllers, or other controllers along with the system card rack and suitable system interface equipment and controller software.

The phase selector will be a plug-in, two or four channel, multiple-priority device intended to be installed directly into a card rack located within the controller cabinet.

The phase selector will be powered from 115 volt (89 volts AC to 135 volts AC), 60Hz mains and will contain an internal, regulated power supply that supports up to twelve infrared detectors. The phase selector may also operate on 24 VDC.

The phase selector will have the capability of storing up to 10,000 of the most recent priority control calls, probe frequency passages, or unauthorized vehicle occurrences. When the log is full, the phase selector will drop the oldest entry to accommodate the new entry. The phase selector will store the record in non-volatile memory and will retain the record if power terminates.

All equipment and cabling necessary for the operation of the Preempt System shall be supplied and installed by the contractor to Global Traffic Technologies specifications. Software configuration and system testing of the Preempt System shall be completed by the City Traffic Division personnel.

H. GROUNDING SYSTEM

An equipment grounding conductor (EGC) shall be installed to electrically bond together all noncurrent carrying conductive materials, including cabinets, poles, pull boxes and raceways, to form an effective ground-fault current path to the overcurrent protective device (breaker) at the service location, as per NEC section 250.4(A)(5). The earth shall not be used as the sole equipment grounding conductor or effective ground-fault path. The EGC shall be electrically isolated from A.C. Neutral in the controller cabinet.

The EGC shall be copper XHHW insulated wire sized per NEC section 250.122. Stainless steel fasteners and copper compression lugs shall be used. Use a specification grade bonding bushings, with stainless steel and hot dip galvanized construction. Use a listed copper conductive compound on all threads and conductors.

The grounding system at the service disconnect shall consist of four 5/8 inch by 10 foot copper clad ground rods placed 15 feet in opposite directions away from the utility pole. The ground rods shall be connected using connectors to #2/0 copper cable. Bolt type clamps shall not be used. A common #2/0 copper cable may be connected into the disconnect equipment with the four cables being spliced at the base of the pole.

The Controller cabinet shall be grounded via a #6 copper wire to a 5/8 inch X 10 foot copper clad ground rod located in a handhole a minimum distance of 15 feet away from the Controller cabinet. No ground rods may be installed within the cabinet.

A 5/8 inch by 10 foot copper clad ground rod shall be installed at each lighting standard and traffic signal pole. These rods shall be interconnected to each other and the service panel.

Interconnection conductors shall be a minimum of #6 copper wire and have an insulation type of TW or approved equal. The rod shall be offset below grade to extend into earth and be centered in base in top end of concrete and extend approximately 6 inches above concrete.

All loop detector lead-in cables shall have the drain shield wire grounded at the point where the loop wires are connected to the lead-in cables. The drain shield wire shall be removed and covered at the cabinet.

The loop lead-in grounding system shall not be connected to or come in contact with any portion of the remainder of the AC grounding system.

I. CONTRACTOR COORDINATION

The Contractor shall coordinate with the City of Council Bluffs Permits & Inspections Department and the local power company for the electrical connection for the 120 VAC power source to the Controller.

Conduit and wire as specified in the plans shall be furnished and installed from the point of the power source to the cabinet. The cost of furnishing and installing this conduit and wire and the termination shall be considered incidental to the project and no additional bid item is provided other than the installation of the Controller. All conduit, wiring, and power service installations shall meet or exceed current National Electrical Codes and any other applicable local codes and ordinances.

The Contractor is required to coordinate with the various utilities in order to obtain clearances required for the installation of conduit and other accessories required to install the complete signal system. All costs incurred in the obtaining of space, marking, defining and coordination are considered incidental to the installation of the Controller.

J. GUARANTEE

The equipment furnished under this specification shall be new, of the latest model, fabricated in a first-class workmanship manner from good quality material.

The entire Controller unit shall be warranted to be free from defects in workmanship and materials for a minimum of one year from date of acceptance. Any part(s) found to be defective, upon concurrence of the defect by the manufacturer, shall be replaced or repaired free of charge.

The City of Council Bluffs shall be furnished with a certification from the equipment manufacturer stating that the equipment furnished under this specification complies with all provisions of this specification. If there are any items, which do not comply with this specification, then a list of those exceptions must be detailed on the certification and on the equipment submittals for the project. Failure to submit a list of exceptions on either the equipment submittals or the certification shall be deemed to be compliance with all issued specifications. Should deviations from the specification be determined from either the review of the equipment submittals or the installation of the hardware into the complete system, the Contractor shall be provided 30 days to correct the deviation(s) before rejection of the project and removal of the equipment.

K. VEHICULAR SIGNAL HEADS

All vehicular signal heads shall be constructed with 12 inch diameter lens openings. All components of the vehicular signal heads furnished under this specification shall comply with the latest version of the Institute of Transportation Engineers Standard(s) for Adjustable Face Vehicle Traffic Control Signal Heads.

Lenses shall be 12 inches in diameter and shall be polycarbonate. Glass lenses are not acceptable. The lenses shall have an optimal curvature to allow maximization of heat dissipation within the signal (reflector to lens) and reduce the possibility of lens burning.

Visors shall be tunnel type and at least 9 1/2 inches long. Reflectors shall be Alzak treated aluminum or glass. All external signal hardware and fasteners of the signal shall be stainless steel, including hinge pins and latching mechanisms.

The optical unit of the signal shall be of a design to permit the opening of the signal face for relamping of the signal without the removal of the lamp socket from the reflector assembly.

The color of all polycarbonate signal heads, except door fronts and inside and outside of visors, shall be federal yellow. Door fronts and inside and outside of visors shall be black in their entirety. The color of the material shall be an integral part of the materials composition.

All signal head assemblies shall be rigid mounted utilizing a suitable assembly consisting of both top and bottom brackets and easily adjustable in both the horizontal and vertical planes. Bracket assemblies shall be of a design similar to that shown on the plans. Bracket assemblies shall be aluminum.

All signal heads placed on mast arms shall be provided with backplates. Backplates shall be of five inch borders and be attached to the signal heads in accordance to city standards.

Backplates shall be constructed of one-piece vacuum formed durable black plastic capable of withstanding a 100 mph wind, excluding five section signal displays. The outer edge of the backplate shall utilize a stabilizer formed from the same material as the backplate. The backplates shall be attached to the signal heads utilizing appropriate machine screws, fender washers and locking nuts as per details.

Lenses shall be 12 inches in diameter as specified in the plans. Red, yellow and green LED lenses shall be used in all signal heads. LED lenses shall meet the following ITE specification: Vehicle Traffic Control

Signal Heads – Part 2: Light Emitting Diode (LED) Vehicle Traffic Control Signal Modules, AN Interim Purchase Specification of the Institute of Transportation Engineers.

The unit shall be mounted and appear as a normal indication within the signal head. All standard arrows shall utilize LED technology signal displays.

All Ball Signal Module LEDs shall be fully compliant to the latest version of the ITE Vehicle Traffic Control Signal Heads (VTCSH) LED Circular Supplement specifications. All LED 12 inch Arrow Signal Modules shall be fully compliant to the latest version of the "Omnidirectional" specifications of the ITE VTCSH -LED Vehicle Arrow Traffic Signal Supplement.

The on-board circuitry of all LED traffic signal modules shall include voltage surge protection, to withstand high-repetition noise transients and low-repetition high-energy transients as stated in Section 2.1.8, NEMA Standard TS 2-2003. In addition, the module shall comply with the following standards: IEC 1000-4-5 at 3kV with a 2 ohm source impedance, ANSI/IEEE C62, 41-2002; IEC 61000-4-12 (6kV, 200A, 100kHz ring wave).

L. PEDESTRIAN SIGNAL HEADS

The pedestrian head assemblies shall conform to the following. The pedestrian signal head shall comply with the latest version of the Institute of Transportation Engineers Standards on Pedestrian Traffic Control Signal Indications and the Manual on Uniform Traffic Control Devices.

The countdown pedestrian signal head shall be a stacked two-section head with 12 inch lenses or one 18 inch section with side-by-side indications as shown on the plans.

SIGNAL HEAD ASSEMBLY:
The signal head shall use the international symbols WALKING PERSON (symbolizing WALK) and PRAISED HAND (symbolizing DONT WALK), and countdown numbers that is installed to direct pedestrian traffic at a traffic control signal. The head is comprised of pedestrian signal housing and a pedestrian signal indication that fits within the housing.

Lenses shall be polycarbonate; glass lenses are not acceptable. A polycarbonate signal housing that protects the light source and other required components and includes an indication mounting door and sun visor shall be used.

All pedestrian signal indications shall be LED. The "walking person" symbol, "raised hand" Symbol, and countdown indication shall be a LED display. All LED signal indications shall meet ITE specifications for signal color and intensity.

The "upraised hand" symbol and countdown digits shall be Portland orange and the "walking person" symbol shall be lunar white.

The color of all polycarbonate signal heads, except door fronts and inside and outside of visors, shall be federal yellow. Door fronts and inside and outside of visors shall be black in their entirety. The color shall be an integral part of the materials composition.

Pedestrian signal mounting hardware shall consist of 1 1/2 inch diameter polycarbonate with appropriate fittings and shall be federal yellow. Pedestrian signals shall be secured to pole by using a minimum 5/8 inch wide stainless steel band.

The pedestrian signal head shall include polycarbonate visors for each section. Visors shall be a minimum of 9 inches long.

The one-section pedestrian head shall include a 1 1/2 inch deep egg crate or Z-crate screen of polycarbonate.

M. PEDESTRIAN PUSH BUTTONS

The pedestrian push button shall be pressure activated, with no moving parts. The pedestrian push button shall provide audible and visual feedback of actuation. The feedback indications shall be powered by the existing switch wires.

CONSTRUCTION:
The push button body shall be constructed of aluminum with a yellow powder coated finish. The button material shall be stainless steel.

SOLID STATE SWITCH:
The push button shall be equipped with a solid state switch with these characteristics:

- Operating force no greater than 3 pounds
- Operating temperature shall be -30°F to 165°F
- Operating voltage shall be 15-36V DC or 12-28V AC
- On resistance shall be 10 Ω typical
- Operating life shall be greater than 100 million operations
- Switch hold time shall be 6 seconds minimum

Operating Standby Current shall be 10μA typical (equivalent to 2M Ω at 20V) LED. The LED indicator shall display an approx. 0.025 second red flash each time the button is pressed, with a luminous intensity of greater than 1200 mcd, and a viewing angle of 160 degrees or greater.

BEEPER:
The beeper shall sound simultaneously with the LED flash. The beeper shall emit separate tones for press and release.

SIGN:
An MUTCD R10-4e sign shall be provided and installed by the contractor.

N. ARMS AND POLES

All standard sized poles and mast arms shall be fabricated from City of Council Bluffs preapproved traffic signal pole design standards. Mast arm lengths will be selected by matching the required size to the nearest five foot interval available. All mast arms will be equal to or greater in length to the five foot intervals. In the event special sized poles and mast arms are required for a signalization project, the Contractor shall submit from the pole manufacturer calculations of all loads transmitted to the bases prior to fabrication. Calculations shall be stamped by a registered professional engineer in the State of Iowa. All calculations shall be submitted with shop drawings and shall be reviewed by the Engineer prior to fabrication.

O. POLE BASES

All concrete pole bases shall be designed as per the standard plans. All standard bases shall use the City of Council Bluffs Class "A" Concrete specifications for 4000 PSI concrete. When special bases are required, all calculations of all loads transmitted to the bases shall be submitted prior to fabrication. A registered professional engineer in the State of Iowa shall stamp calculations. All calculations shall be submitted with drawings and shall be reviewed and approved by the Engineer prior to fabrication.

P. CONDUIT AND CONDUIT FITTINGS

Conduit and conduit fittings for direct bury applications shall be galvanized rigid steel conforming to UL-6, UL Standard for Safety for Electrical Rigid Metal Conduit – Steel; high-density polyethylene conforming to ASTM F2160, Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD); or rigid polyvinyl chloride conforming to UL-651, UL Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit.

Conduit and conduit fittings for boring applications shall be high density polyethylene conforming to ASTM D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter. Furnish in standard lengths with UL label.

Rigid steel conduit fittings shall be galvanized steel or galvanized malleable iron. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. PVC conduit fittings and cement shall be compatible with the PVC conduit. Transitions between HDPE and PVC conduits shall conform to the manufacturer's recommendations. Conduit size shall be the minimum trade size permitted for the application and shall have a constant circular cross sectional area. Conduit installed for above ground risers shall be galvanized rigid steel conduit.

Q. ELECTRICAL CABLE

Electrical cable for intersection signalization shall be rated 600 volts minimum and be IMSA specification cable where applicable.

The number of conductors and size of all electrical cable shall be as shown on the plans.

All wire shall be plainly marked on the outside of the sheath with the manufacturer's name and identification of the type of the cable.

All conductors used in the Controller cabinet shall be a minimum of No. 22 AWG (or larger, if required by the amperage requirements of the particular circuit), tinned copper conductors with a minimum of 19 strands, and shall conform to Federal Specifications IL-W-16878D, Type B or D, Vinyl-Nylon Jacket, 600 volts, 105°C, equal or better.

Conductors used in the Controller cabinet shall conform to the NEC color codes:

- C. Neutral White
- C. Line Black
- Chassis, Safety Ground Green
- Control Any color not listed above

POWER LEAD-IN CABLE:

- Power lead-in cable shall be of the sizes as shown on the plans.
- Power lead-in cable shall be 600 volt, single conductor, stranded copper, Type USE, and UL approved.

SIGNAL CABLE:
Signal cable shall be 600 volt, multi-conductor, with copper conductor of the number and size as shown on the plans.

Signal cable shall meet the requirements of the International Municipal Signal Association (IMSA) specification 19-1, latest revision thereof for polyethylene insulated, polyvinyl chloride jacketed signal cable. All conductors shall be No. 14 AWG unless otherwise specified on the plans.

LOOP DETECTOR WIRE (WITH PLASTIC TUBING):
The loop wire shall meet the requirements of the International Municipal Signal Association (IMSA) specification 51-5, latest revision thereof for a nylon or crosslinked polyethylene jacketed conductor, loosely encased in a polyethylene tube loop detector wire. The conductor shall be No. 16 AWG unless otherwise specified on the plans.

DETECTOR LEAD-IN CABLE:
Detector lead-in cable shall meet the requirements of the international Municipal Signal Association (IMSA) specification 50-2, latest revision thereof for polyethylene insulated, polyethylene jacketed loop detector lead-in cable. All conductors shall be No. 14 AWG unless otherwise specified on the plans.

COMMUNICATIONS CABLE (TELEPHONE) (WHEN APPLICABLE):
Traffic control communications cable for signal interconnection circuits shall be No. 19 AWG, solid copper conductor, twisted pairs. The cable shall meet the requirements of the International Municipal Signal Association (IMSA) specification 39-2, latest revision thereof for paired polyethylene insulated, polyvinyl chloride jacketed cable with electrical shielding.

The number of twisted pairs required shall be as shown on the plans (minimum of two pairs).

TRACER CABLE:
A tracer cable shall be installed in all conduits with signal cables, detector lead-in cables, or fiber optic communication cables.

The tracer cable shall be a single conductor, stranded copper, No. 12 AWG, Type THHN, with UL approval and an orange colored jacket.

The tracer cable shall be identified in the Controller cabinet, handholes, and poles by means of identification tags.

GROUNDING CABLES:
The EGC shall be copper XHHW insulated wire sized per NEC section 250.122. Stainless steel fasteners and copper compression lugs shall be used. Use a specification grade bonding bushings, with stainless steel and hot dip galvanized construction. Use a listed copper conductive compound on all threads and conductors.

Grounding conductors within lighting standards and traffic signal poles shall be a #6 copper cable.

All grounding conductors that connect bonding bushings to grounding systems shall be a #6 copper cable.

All grounding conductors between terminal strip support plates and the cabinet grounding bus shall be a minimum of a #10 copper cable or a braided copper cable with equal cross sectional area.

R. LOOP DETECTORS

PREFORMED LOOPS:
In all projects where new pavement is to be placed in the loop areas and wherever possible and practical, preformed loops shall be installed within or under the pavement in lieu of pavement sawn loops. The Engineer shall be notified when the Contractor requests to substitute pavement sawn loops for preformed loops and the Engineer shall determine if the request should be approved. Preformed loops may either be manufactured by an approved supplier, or built by the contractor.

Currently approved manufactured preformed loops are: 1) Patriot Detection Systems model CG16MMC, and 2) Reno A&E model PLH. Equivalent products may be approved by the City Traffic Engineer.

Preformed loops built by the contractor shall consist of 1/2 inch rigid polyvinyl chloride conduit with approved IMSA loop wire conductors placed within the conduit. The conductors within the conduit shall be held firmly in place by a filler material such as backer rod, expanding foam, or silicone based sealants, which will remain flexible and provide rigidity to the conductors throughout the life of the preformed loop.

The conduit shall be thoroughly solvent welded to prevent moisture infiltration and provide mechanical strength to the loop. A PVC pulling elbow shall be placed at the point where the lead-in point meets the edge of the loop.

When installed, no part of the loop shall be within 2 feet of reinforcement rods in the surrounding pavement.

The loop should not be situated directly over any large metal object in the ground within 5 feet of the surface.

SAWCUT LOOPS:

LOOP WIRE:

The detector loop wire shall be inserted into a flexible plastic tubing (IMSA Specification 50-2-1984) of the full length from the point of the splice and placed into the slot with the number of turns specified. The tubing shall be of a continuous length from the point of splicing of the loop wire to the lead-in cable. The field loop conductors installed in the pavement shall run continuously from the terminating service box or base with no splices permitted. The field loop conductors shall be spliced to the lead-in cable and the lead-in cable shall run continuously from the terminating service box or base to the detector sensing unit. However, on multiple loop installations additional loop conductors may be spliced to the lead-in cable as directed by the Engineer. At the time of placing the loop wire in the sawed slots, the ends of the tubing shall be sealed to prevent any entrance of moisture into the tubing.

WIRE TWISTING:

Wherever possible in order to reduce line noise, all lengths of loop wires and tubing that are not embedded in the pavement shall be twisted with at least five turns per foot, including lengths in conduits and service boxes.

LOOP WIRE SPLICES*:*

The wires shall be spliced by soldering iron using 40/60 rosin core solder only. The solder joint shall be smooth and provide proper physical bonding of the conductors. A flame shall not be used for soldering.

The wire portion of the splice shall be covered with a layer of heat shrink tubing. The heat shrink shall be secured by an electrical heat gun with heat reflector to insure uniform heat distribution on the tube. No flame may be used on the heat shrink tubing.

The final layer of heat shrink tube shall be an outdoor rated heavy-wall, cross-linked polyolefin heat shrink tubing. The tubing shall be centered with a minimum of 1 inch of the outer jacket being encapsulated by the heat shrink tubing.

Lead-In cable to loop wire splices shall be soldered together leaving only enough exposed insulation and conductor to make the splice.

Loop wire to lead-in cable splices shall be environmentally sealed against weather, moisture and abrasion using a commercially available encapsulating enclosure kit.

LOCATION OF LOOPS:

The location of each loop shall be marked on the pavement with crayon or spray paint. The Contractor shall obtain the approval of the Engineer prior to cutting the saw slots.

CONCRETE SAWING:

The saw shall be equipped with a depth gauge and horizontal guide to assure proper depth and alignment of the slot. The blade used for the saw cut shall provide a clean, straight, well-defined 3/8 inch wide saw cut without damage to adjacent areas. The depth of the saw cut shall be 2 inches deep. Where the loop changes direction, the saw cuts shall be overlapped to provide full depth at all corners. All adjacent cuts must be at angles greater than or equal to 90 degrees. The saw cut depth shall not vary by more than 1/4 inch within each loop. A diamond blade with water shall be used in the saw cut operation. Carbide blades are not acceptable.

LOOP SLOTS:

Before installing loop wire, the saw slots shall be checked for the presence of jagged edges or protrusions. Should they exist, they must be removed. The slots shall be cleaned and dried to remove cutting dust, grit, oil, moisture or other contaminants. Cleaning shall be achieved by flushing with a stream

of water under a minimum of 1000 PSI pressure and following, the slots shall be cleared of water and dried using oil-free air.

LOOP CONDUCTOR INSTALLATION:
Loop detector conductor shall be installed using a 3/16 inch to 1/4 inch thick wood paddle or rotary wire insertion tool. If the wire does not lie close to the bottom of the saw cut, it shall be held down by means of a material such as duct sealant or backer rod.

LOOP WIRE PLACEMENT:
Each loop shall be coiled clockwise unless specified within the plans. The beginning conductor shall be marked with a single color-coded piece of permanent tape and the associated end marked with two pieces of permanent tape of the same color. The markings shall be recorded for future information.

LOOP DETECTOR SAW SLOT FILLER:
The saw slot filler shall be a rapid cure, high viscosity, liquid epoxy, or approved equal, formulated for use in sealing inductive wire loops and leads embedded in asphaltic concrete and portland cement concrete. The saw slot filler shall be usable on grades of 15% or less without excessive flow of material, unless otherwise approved by the Engineer.

The loop sealer or sealant shall be a two-component system, which consists of, a resin constituent identified as pourable and a hardener identified as quick setting. The sealer shall be Bondo P-606 for concrete and seasoned asphalt, E709 for new asphalt; WR Meadows Sealex; 3M Detector Loop Sealant Series 5000; or equal, as approved by the Engineer. Both the resin and the hardener shall be in liquid form before mixture of the two components.

Approval of other sealants shall be based on specification and/or test data about their physical properties and chemical resistance. Loop sealant shall not be installed during rain or other forms of precipitation or below temperatures specified by the manufacturer of the product. The cured sealer shall be unaffected by oils, gasoline, grease, acids and most alkalis. The mixing of components and the filling of the cut shall be in accordance with the directions of the manufacturer.

No measurable amount of sealant shall be left on the surface of the pavement and the sealant within the saw cut shall be level with the pavement surface.

LOOP TESTING:
After installation of the loops, the Contractor shall test the continuity, inductance, and resistance of the loop and lead-in wire. Tests should be conducted with one or more loop tester devices capable of measuring the induced ac voltage, inductance in microhenrys (µH), integrity of the wire insulation, and loop wire resistance in ohms.

The wiring diagram of the plan set or the inspection report should include a table of calculated values of the inductance in microhenrys and resistance in ohms for each loop.

Two values should be shown: one at the pull box without the lead-in cable, and the second at the controller cabinet with the lead-in cable connected.

The loop installation is acceptable under the following conditions:

- Induced voltage: There is no deflection of the pointer on a voltmeter.
- Inductance: The inductance reading on the loop tester is within 10% of calculated value.
- Leakage to ground: The resistance to ground of a newly installed loop exceeds 100 megohms as measured with a 500 volt (V) megger.
- Loop resistance: The reading on an ohmmeter is within 10% of the calculated value.
- The total loop system (loop plus lead-in) inductance is within the acceptable range of the vehicle detector specified in the plan.
- The detector system (loops + lead-in + electronic detector) shall be capable of reliably detecting all licensed vehicles.

The Contractor shall provide the Engineer with a report on company letterhead indicating the inductance, leakage to ground, and loop resistance test values for each loop. The test shall be conducted from the curbside handhole. An inductance, leakage to ground, and loop resistance test shall also be conducted and reported for the total detector lead-in and loop system with the test being conducted at the Controller cabinet. The City Traffic Engineer may independently test any or all loops at any time. Any Loop not meeting the requirements for an acceptable loop installation shall be repaired or replaced as directed by the Engineer. The Contractor shall bear all costs of replacing loop installations deemed unsatisfactory by the Engineer.

S. WIRE SPLICING

No below grade splicing of any traffic signal wiring, except loop to loop lead-in cable, shall be allowed. All splices shall be made in signal pole bases or approved above grade enclosures.

Wires being spliced shall be twisted in a clockwise direction in order that solderless connectors are forced onto the splice.

Solderless connectors and splice cap covers shall be secured and made water tight with either vinyl electrical tape or a liquid insulating sealant equivalent to Scotchkote electrical coating.

All exposed single layer insulation, splice cap covers, and solderless connectors shall be encapsulated in rubber electrical tape. This is to provide a cushion to the single layer of insulation.

The rubber tape shall be encapsulated in a layer of vinyl electrical tape. All portions of the tape are to be smooth and well secured.

All splices shall be oriented with the splice above the spliced wire to avoid water collecting in the splice.

Two nylon tie straps shall then be secured approximately two inches beyond the wire splice at one inch increments to act as a strain relief to the splice.

T. STREET LIGHTS

When roadway lighting is specified as part of the signalization project, all luminaires shall be 250 Watt High Pressure Sodium fixtures with a flat glass lamp protector, medium cutoff, magnetic regulation ballasts, 120 volt, and be a commercial rated cobra head design. The lighting pattern shall meet ANSI photometric requirements and shall be Type III light distribution unless shown otherwise on the plans.

This specification is subject to change where other type of lighting is called out on the signal plans.

U. SIGNAL HEAD COVERS

During construction all signal heads shall be covered with black vinyl covers specifically designed for this purpose. The covers shall be fastened to the heads with nylon straps utilizing a cam lock mechanism to secure the straps. Plastic bags, cardboard, burlap and other similar materials are not acceptable covers.

V. RADAR VEHICLE DETECTORS

A Radar Vehicle Detection System shall be installed for the purposes of providing vehicle presence (stop bar) detection at the project intersections. The Radar Vehicle Detectors shall be of the type shown on the drawings and specified herein and shall be installed in the locations shown on the plans. The Radar Vehicle Detectors shall detect vehicles by transmitting electromagnetic radar signals through the air. The signals bounce off vehicles in their paths and part of the signal is returned to the detector. The returned signals are then processed to determine traffic parameters. These detectors are intended to work well in any environment and not be affected by normal weather and conditions such as rain, wind, snow, dust,

etc. They shall not require cleaning and can maintain performance over a wide range of ambient temperatures.

RADAR VEHICLE DETECTORS:
The radar vehicle detector shall include all the cables, connectors, and mounting hardware recommended by the manufacturer for proper operation of the system. This includes any necessary cabinet components, surge protection, and terminal blocks for cable landing.

PERFORMANCE:
The radar vehicle detector shall meet or exceed the following requirements:

Sensor Outputs:

- shall present real-time presence data in ten lanes
- shall support a minimum of 16 zones
- support a minimum of 16 channels
- support user-selectable zone to channel mapping
- shall use AND logic to trigger channels when all selected zones are active
- shall use OR logic to combine multiple zones to a channel output, and shall have channel output extend and delay functionality
- algorithms shall mitigate detections from wrong way or cross traffic
- shall have fail-safe mode capabilities for contact closure outputs if communication is lost

DETECTABLE AREA:
The detectors shall have the following detectable area characteristics:

Detection Range:

- shall be able to detect and report presence in lanes with boundaries as close as 6 feet from the base of the pole on which the detector is mounted
- shall present real-time presence data in ten lanes
- shall support a minimum of sixteen zones
- shall be able to detect and report presence in lanes located within the 140 foot arc from the base of the pole on which the detector is mounted

FIELD OF VIEW:
The detectors shall be able to detect and report presence for vehicles within a 90 degree field of view.

LANE CONFIGURATION:
The detectors shall be able to detect and report presence in curved lanes and areas with islands and medians.

SYSTEM HARDWARE:
For each approach to be detected, one corner radar unit shall be used.

PREASSEMBLED BACKPLATE:
The radar detectors shall have a traffic cabinet preassembled backplate with the following:

- AC/DC power conversion
- Surge protection
- Terminal blocks for cable landing
- Communication connection points

CONTACT CLOSURE INPUT FILE CARDS:
The detectors shall use contact closure input file cards with two or four channel capabilities. The contact closure input file cards shall be compatible with industry standard detector racks.

PHYSICAL PROPERTIES:

The radar vehicle detectors shall not exceed 4.2 pounds in weight. Their dimensions shall not exceed 14 inches by 11 inches by 4 inches in its physical dimensions. All external parts of the detector units shall be ultraviolet-resistant, corrosion-resistant, and protected from fungus growth and moisture deterioration.

ENCLOSURE:
The radar detectors shall be enclosed in a durable, high performance, polycarbonate copolymer. The enclosure shall be classified "fl" outdoor weatherability in accordance with UL 746C. The detector units shall be classified as watertight according to the NEMA 250 standard and shall conform to test criteria set forth in the NEMA 250 standard for type 4X enclosures.

Test results shall be provided for each of the following type 4X criteria:
- External icing (NEMA 250 clause 5.6)
- Hose-down (NEMA 250 clause 5.7)
- 4X corrosion protection (NEMA 250 clause 5.10)
- Gasket (NEMA 250 clause 5.14)

The radar vehicle detectors shall be able to withstand a drop of up to 5 feet without compromising its functional and structural integrity. The enclosure shall include a connector that meets the MIL-C-26482 specification. The MIL-C-26482 connector shall provide contacts for all data and power connections.

ELECTRICAL:
The radar vehicle detectors shall individually consume less than 10 W. They shall operate with a DC input between 9 VDC and 28 VDC. The units shall have onboard surge protection.

CABLING:
The cable end connector shall meet the N.IILC- 26482 specification and shall be designed to interface with the appropriate MIL-C-26482 connector. The connector backshell shall be an environmentally sealed shell that offers excellent immersion capability. All conductors that interface with the connector shall be encased in a single jacket, and the outer diameter of this jacket shall be within the backshell's cable O.D. range to ensure proper scaling. The backshell shall have a strain relief with enough strength to support the cable slack under extreme weather conditions.

The cable shall conform to the following specifications:
- The RS-485 conductors shall be a twisted pair.
- The RS-485 conductors shall have nominal capacitance conductor to conductor of less than 40 pF/ft at 1 kHz.
- The RS-485 conductors shall have nominal conductor DC resistance of less than 16.7 ohms/1000 feet at 68ºF.
- The RS-485 conductors shall be terminated in the factory (NO field termination will be permitted).
- The power conductors shall be one twisted pair with nominal conductor DC resistance of less than 11.5 ohms/1000 feet at 68°F.
- Each wire bundle or the entire cable shall be shielded with an aluminum/mylar shield with a drain wire. The cable shall be terminated only on the two farthest ends of the cable. The cable length shall not exceed 2000 feet for the operational baud rate of RS-485 communications (9.6 Kbps). Both communication and power conductors can be bundled together in the same cable as long as the abovementioned conditions are met.

COMMUNICATION PORTS:
The radar vehicle detectors shall have two communication ports, and both ports shall communicate independently and simultaneously. Two independent communication ports allow one port to be used for configuration, verification and traffic monitoring without interrupting communications on the dedicated data port. The radar vehicle detectors shall support the upload of new firmware into the unit’s non-volatile memory over either communication port.

The detectors shall support the user configuration of the following:

- Response delay
- Push port

The communication ports shall support a 9600 bps baud rate.

RADAR DESIGN:
The radar vehicle detectors shall be designed with a matrix of radars. The matrix of radars enables the sensor to provide detection over a large area and to discriminate lanes. Frequency Stability The circuitry shall be void of any manual tuning elements that could lead to human error and degraded performance over time.

All transmit modulated signals shall be generated by means of digital circuitry, such as a direct digital synthesizer, that is referenced to a frequency source that is at least 50 parts per million (ppm) stable over the specified temperature range, and ages less than 6 ppm per year. Any upconversion of a digitally generated modulated signal shall preserve the phase stability and frequency stability inherent in the digitally generated signal.

This specification ensures that, during operation, the radar detectors strictly conforms to FCC requirements and that the radar signal quality is maintained for precise algorithmic quality. Analog and microwave components within a detector have characteristics that change with temperature variations and age. If the output transmit signal is not referenced to a stable frequency source, then the detector is likely to experience unacceptable frequency variations which may cause it to transmit out of its FCC allocated band and thus will be non-compliant with FCC regulations.

The radar detectors shall not rely on temperature compensation circuitry to maintain transmit frequency stability.

The bandwidth of the transmit signal of the detectors shall not vary by more than 1% under all specified operating conditions and over the expected life of the RPD.

ANTENNA DESIGN:
The detector antennas shall be designed on printed circuit boards. The vertical beam width of the radar detectors at the 6 dB points of the two-way pattern shall be 65 degrees or greater. The antennas shall cover a 90 degree horizontal field of view.

RESOLUTION:
The radar detectors shall transmit a signal with a bandwidth of at least 245 HHz.

RF CHANNELS:
The radar detectors shall provide at least eight RF channels so that multiple units can be mounted in the same vicinity without causing interference between them.

VERIFICATION:
The radar detectors shall have a self-test that is used to verify correct hardware functionality. The units shall have a diagnostics mode to verify correct system functionality.

CONFIGURATION:
The radar vehicle detectors shall have the following configuration characteristics:

AUTO-CONFIGURATION:
The radar detectors shall have a method for automatically defining traffic lanes, stop bars and zones without requiring user intervention. This auto-configuration process shall execute on a processor internal to the radar detectors and shall not require an external PC or other processor. The auto-configuration process shall work under normal intersection operation and may require several cycles to complete.

MANUAL CONFIGURATION:
The auto-configuration method shall not prohibit the ability of the user to manually adjust the radar detectors configuration. The radar detectors shall support the configuring of lanes, stop bars and detection zones in 1 foot increments.

WINDOWS® MOBILE-BASED SOFTWARE:
The radar detectors shall include graphical user interface software that displays all configured lanes and the current traffic pattern using a graphical traffic representation. A visual representation of traffic patterns allows an installer to quickly associate specific detections with corresponding vehicles, and it facilitates verification of RPD performance. The graphical interface shall operate on Windows Mobile, Windows XP, Windows Vista and Windows 7 in the NET framework.

The software shall support the following functionality:

- Operate over a TCP/IP connection
- Give the operator the ability to save/back up the RPD configuration to a file or load/restore the RPD configuration from a file
- Allow the backed-up sensor configurations to be viewed and edited
- Provide zone and channel actuation display
- Provide a virtual connection option so that the software can be used without connecting to an actual sensor
- Local or remote sensor firmware upgradability

OPERATING CONDITIONS:
The radar detectors shall maintain accurate performance in all weather conditions, including rain, freezing rain, snow, wind, dust, fog and changes in temperature and light, including direct light on sensor at dawn and dusk. The radar detectors operation shall continue in rain up to 1 inch per hour. The radar detectors shall be capable of continuous operation over an ambient temperature range of -40°F to 165.2°F. The radar detectors shall be capable of continuous operation over a relative humidity range of 5% to 95% (non-condensing).

TESTING:
The radar vehicle detectors shall be tested at the factory and provide verification of such.

FCC:
Each radar detectors shall be certified by the Federal Communications Commission (FCC) under CFR 47, part 15, section 15.249 as an intentional radiator. The FCC certification shall be displayed on an external label on each RPD according to the rules set forth by the FCC. The radar detectors shall comply with FCC regulations under all specified operating conditions and over the expected life of the RPD.

NEMA TS 2-2003 TESTING:
The radar detectors shall comply with the applicable standards stated in the NEMA TS 2-2003 standard.

Third party test results shall be made available for each of the following tests:

- Shock pulses of 10 g, 11 ms half sine wave
- Vibration of 0.5 g up to 30 Hz
- 300 V positive/negative pulses applied at one pulse per second at minimum and maximum DC supply voltage
- Cold temperature storage at -49°F for 24 hours
- High temperature storage at 185°F for 24 hours
- Low temp, low DC supply voltage at -29.2°F and 10.8 VDC
- Low temp, high DC supply voltage at -29.2°F and 26.5 VDC
- High temp, high DC supply voltage at 165.2°F and 26.5 VDC
- High temp, low DC supply voltage at 165.2°F and 10.8 VDC

The internal electronics of the radar detectors shall utilize automation for surface mount assembly, and shall comply with the requirements set forth in IPC-A-610C Class 2, Acceptability of Electronic Assemblies. The radar detectors shall undergo a rigorous sequence of operational testing to ensure product functionality and reliability.

Testing shall include the following:

- Functionality testing of all internal sub-assemblies
- Unit level burn-in testing of 48 hours' duration or greater
- Final unit functionality testing prior to shipment

Test results and all associated data for the above testing shall be provided for each purchased radar detectors by serial number, upon request.

SUPPORT:
The radar detectors manufacturer shall provide both training and technical support services.

TRAINING:
The manufacturer-provided training shall be sufficient to fully train installers and operators in the installation, configuration, and use of the radar detectors to ensure accurate performance. The manufacturer-provided training shall consist of comprehensive classroom labs and hands-on, in the field, installation and configuration training. Field training shall provide each trainee with the hands-on opportunity to install and configure the RPD at roadside. Training shall be such that each trainee will mount and align the RPD correctly.

TECHNICAL ASSISTANCE:
Manufacturer-provided technical support shall be available, and a technical representative shall be available to assist with the physical installation, alignment, and auto-configuration of each supplied radar detectors. Technical support shall be provided thereafter to assist with troubleshooting, maintenance, or replacement of radar detectors should such services be required.

DOCUMENTATION:
Radar vehicle detection system documentation shall include an instructional training guide and a comprehensive user guide as well as an installer quick-reference guide and a user quick-reference guide.

The radar detectors manufacturer shall supply the following documentation and test results at the time of the bid submittal:

- FCC CFR 47 certification (frequency compliance)
- IED 6100-4-5 class 4 test report (surge)

WARRANTY:
The radar vehicle detectors and all related system components shall be warranted free from material and workmanship defects for a period of three years from date of installation.

CONSTRUCTION REQUIREMENTS:
The Radar Vehicle Detectors and System shall be installed in accordance with the Vendor’s recommended procedure. When the set up is complete and the system is ready for operation, the values of all parameters that were set during the process shall be delivered to the Engineer in printed or computer-readable form.

W. SCHEDULE OF UNIT PRICES

Prior to the preconstruction meeting the traffic signal contractor shall forward to the engineer a list of unit costs for the individual traffic signal items. The sum of costs for each item shall equal the total Contract Lump Sum price for the traffic signal installation. The total cost shall not be unreasonably distributed among the individual unit items.