SP-150666
(New)

SPECIAL PROVISIONS
FOR
TRAFFIC SIGNALIZATION

Pottawattamie County
IM-NHS-029-3(232)53--13-78

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THE STANDARD SPECIFICATIONS, SERIES 2015, 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 Standards Publication No. TS2-2003 including NEMA TS-2 Amendment #4-2012 (for Flashing Yellow Arrow) or latest.

The local intersection controller shall be the most current version of the Cubic|Trafficware Commander Advanced Traffic Controller or an equivalent approved by the Engineer. The controller shall include the data key option or similar function. The local intersection Controller shall be fully compatible with the City of Council Bluff's existing ATMS.now Advanced Traffic Management System manufactured by Cubic|Trafficware. The Controller shall be capable of 10/100 BASE-T Ethernet network communication. The Engineer may specify alternate or additional communications capabilities as needed.

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 also manufacture the traffic control cabinet and all terminal facilities unless otherwise approved by the City of Council Bluffs Traffic Engineer. All other equipment may be multi-source as long as it meets the latest NEMA TS2 specification and is approved by the Engineer.

B. MALFUNCTION MANAGEMENT UNIT

1.0 FUNCTIONS

1.1 GENERAL

This specification sets forth the minimum requirements for a shelf-mountable, sixteen channel, solid-state Malfunction Management Unit (MMU) with Ethernet capability. The MMU shall meet as a minimum, all applicable sections of the *NEMA Standards Publication No. TS2-2003 (R2008)* including *NEMA TS-2*

Amendment #4-2012. Where differences occur, this specification shall govern.

1.1.1 NEMA TS-2 AMENDMENT #4-2012 FOR FLASHING YELLOW ARROW

The MMU shall be fully compliant with the requirements of the *NEMA TS-2 Amendment #4-2012* for Flashing Yellow Arrow. This standard defines the operation of a Type MMU2 device. The MMU itself shall be labeled as an MMU2.

1.2 MONITORING FUNCTIONS

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

1.2.1 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.

When voltages on two inputs of a vehicle channel are sensed as active for more than 450 msec, the MMU(2) shall enter the fault mode, transfer the OUTPUT relay contacts to the Fault position, and indicate the DUAL INDICATION fault. The MMU(2) 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 vehicle channel are sensed as active for less than 200 msec, the MMU(2) shall not transfer the OUTPUT relay contacts to the Fault position.

When operating 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.

1.2.1.1 DUAL INDICATION PROGRAMMING

Programming shall be provided to enable the Dual Indication monitoring function for the Green and Red, Green and Yellow, and Yellow and Red combinations for each individual channel. In the Type 12 mode, the Walk inputs shall be logically OR'ed with the Green inputs for purposes of Dual Indication programming.

1.2.2 FIELD CHECK MONITORING

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.

1.2.2.1 FIELD CHECK MONITOR

In the Field Check Fault mode, when the field signal input states sensed by the MMU(2) do not correspond with the data provided by the Controller Unit in the Type #0 message for 10 consecutive messages, the MMU(2) shall enter the fault mode, transfer the OUTPUT relay contacts to the Fault position, and indicate the FIELD CHECK FAIL fault. 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(2) shall remain in the fault mode until the unit is reset by the RESET button or the EXTERNAL RESET input.

1.2.2.2 FIELD CHECK STATUS

The Field Check Status mode shall work in combination with the other fault monitoring functions of the MMU(2). When a Conflict, Red Fail, Clearance Fail, or Dual Indication Fail triggers the MMU(2), 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 inputs on which the Field Check errors were detected shall be reported on the Channel Status display. Bit #67 (Spare Bit #1) of the Type #129 response frame shall also be set to indicate Field Check errors have been detected.

1.2.2.3 FIELD CHECK PROGRAMMING

Programming shall be provided to enable the Field Check monitoring function for each Green, Yellow, and Red input individually. Programming shall be provided to enable the Field Check monitoring function for channel 2, 4, 6, and 8 Walk input individually when operating in the Type 12 with SDLC mode.

1.2.3 RECURRENT PULSE MONITORING

The Signal Monitor shall detect Conflict, Red Fail, and Dual Indication faults that result from intermittent or flickering field signal inputs. These recurring pulses shall result in a latching fault with the RECURRENT PULSE STATUS indicated along with the resulting Conflict, Red Fail, or Dual Indication status. An option shall be provided to disable the RP detect function for testing purposes.

When operating with Port 1 communications enabled, Bit #69 (Spare Bit #3) of the Type #129 response frame shall be set to indicate a Recurrent Pulse status has been detected.

1.2.4 EXTERNAL WATCHDOG MONITORING

The MMU(2) shall provide the capability to monitor an optional external logic level output from a Controller Unit or other external cabinet circuitry. If the MMU(2) does not receive a change in state on the EXTERNAL WATCHDOG input for 1500 msec (±100 msec), the MMU(2) shall enter the fault mode, transfer the OUTPUT relay contacts to the Fault position, and indicate the WATCHDOG fault. The MMU(2) shall remain in the fault mode until the unit is reset by the RESET button or the EXTERNAL RESET input. An MMU(2) Power Failure shall reset the WATCHDOG fault state of the monitor. The EXTERNAL WATCHDOG input shall be wired to connector MSB-S.

When operating 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.

1.2.5 TYPE FAULT MONITOR

The MMU(2) 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(2) into the fault mode, transfer the OUTPUT relay contacts to the Fault position, and indicate the TYPE 12/16 fault. The MMU(2) shall remain in the fault mode until the unit is reset by the RESET button or the EXTERNAL RESET input. An MMU(2) Power Failure shall reset the Type Fault state of the monitor.

1.2.6 FLASHING YELLOW ARROW PPLT SUPPORT

The MMU(2) shall be designed to monitor an intersection with up to four approaches using the four section Flashing Yellow Arrow (FYA) movement as specified by NEMA TS-2 Amendment #4-2012. Twelve cabinet configurations shall be supported for the MMU(2) Type 16 mode and four modes for the Type 12 mode, in order to support cabinet configurations limited by the number of load switches provided and the capabilities of the Controller Unit. The MMU(2) shall be designed to provide the same fault coverage for the FYA approaches as it does for conventional protected left turn phases, including Conflict, Red Fail, Dual Indication, and both Minimum Yellow and Minimum Yellow Plus Red Clearance monitoring.

1.3 CONFIGURATION OPTIONS

1.3.1 WALK DISABLE OPTION

This option will modify the operation of Red Fail and Dual Indication Monitoring in the TS-1 Type 12 mode only. When enabled, the Red Fail and Dual Indication Monitoring function will not monitor the Walk field outputs. Absence of signals on the Green, Yellow, and Red field outputs of a channel will place the MMU(2) into the Red Fail fault mode causing the Output relay contacts to transfer. Presence of active signals on the Walk output will not cause a Dual Indication when concurrent with active Red or Yellow signals.

1.3.2 LED SIGNAL THRESHOLD ADJUST

The MMU(2) shall provide the capability to sense field inputs signals with the following thresholds:

Conflict, Dual Indication Low Threshold Signal Inputs (Green, Yellow, and Red)

No Detect ..... less than 15 Vrms
Detect ..... greater than 25 Vrms

Red Fail High Threshold Signal Inputs (Green, Yellow, and Red)

No Detect ..... less than 50 Vrms
Detect ..... greater than 70 Vrms

1.3.3 CVM LOG DISABLE OPTION

The MMU(2) shall provide a means to disable the logging of CVM fault events.

1.3.4 CVM 3X/DAY LATCH OPTION

The MMU(2) shall provide a mode for allowing up to two CVM events in a 24 hour period to be non-latching. The third CVM event in a 24 hour period shall be latching. Following the third event a power cycle shall reset the count from 3 to 2. A manual reset shall reset the count to 0.

1.4 DISPLAY FUNCTIONS

The following display functions shall be provided in addition to those required by the NEMA TS-2 Standard Section 4. A PC shall not be required to display the following parameters.

1.4.1 FIELD SIGNAL VOLTAGES DISPLAY

A mode shall be provided to display the RMS voltage of each field signal input. If the MMU(2) is not in the fault mode, the displayed voltage will be the currently applied RMS voltage. If the MMU(2) is in the fault mode, the displayed voltage will be the applied RMS voltage at the time of the fault.

1.4.2 CABINET CONTROL SIGNAL VOLTAGES DISPLAY

A mode shall be provided to display the RMS voltage of the AC Line and Red Enable, the frequency of the AC Line, and the ambient temperature measured at the MMU(2). If the MMU(2) is not in the fault mode, the displayed values will be the currently applied values. If the MMU(2) is in the fault mode, the displayed values will be the applied values at the time of the fault.

1.4.3 FIELD CHECK STATUS DISPLAY

When the MMU(2) is in the fault mode, a display screen for the front panel display shall be provided to identify all field signal inputs with Field Check status.

1.4.4 RECURRENT PULSE STATUS DISPLAY

When the MMU(2) is in the fault mode, a display screen for the front panel display shall be provided to identify all field signal inputs with Recurrent Pulse status.

1.4.5 CONFIGURATION DISPLAY

A display mode for the front panel display shall be provided that allows the setting and viewing of all MMU(2) configuration parameters. The configuration parameters provided on the program card shall be viewable only. A PC shall not be required to completely program or view the MMU(2) configuration parameters.

1.4.6 EVENT LOGS DISPLAY

A display mode for the front panel display shall be provided to review all details of the Previous Fail log, AC Line log, and the Monitor Reset log.

1.4.7 CLOCK SET DISPLAY

A display mode for the front panel display shall be provided to view and set the time and date of the MMU(2) real time clock.

1.5 OPERATING MODES

The MMU(2) shall operate in both the Type 12 mode and Type 16 mode as required by the NEMA Standard.

1.5.1 HELP SYSTEM

A context sensitive Help system shall be provided that is activated by a separate Help button. The Main Status display shall respond with text messages relevant to the position in the menu navigation level. When the MMU(2) is in the fault mode the Help system shall respond with the Diagnostic mode described in 0.

1.5.2 SETUP WIZARD

A built-in setup mode shall be provided that automatically configures the Dual Indication enable, Field Check enable, Red Fail enable, and Minimum Yellow Plus Red Clearance enable parameters from user input consisting only of channel assignment and class (vehicle, ped, pp-turn, etc.) responses.

1.5.3 DIAGNOSTIC WIZARD

A built-in Diagnostic Wizard shall be provided that displays detailed diagnostic information regarding the fault being analyzed. This mode shall provide a concise view of the signal states involved in the fault, pinpoint faulty signal inputs, and provide guidance on how the technician should isolate the cause of the malfunction. The Diagnostic Wizard shall be automatically invoked when the MMU(2) is in the fault mode and the HELP button is pressed. It shall also be automatically invoked when the MMU(2) is in the Previous Fail (PF) event log display and the HELP button is pressed.

1.5.4 TS-1 TYPE 12 WITH SDLC MODE

The MMU(2) shall be capable of operating in the Type 12 mode with SDLC communications enabled on Port 1. The Channel Status display shall operate in the Type 12 configuration and provide the Field Check function for up to four pedestrian Walk inputs.

2. HARDWARE

2.1 ENCLOSURE

2.1.1 SIZE

The MMU(2) shall be compact so as to fit in limited cabinet space. It shall be possible to install on a shelf that is at least 7 inches deep. Overall dimensions, including mating connectors and harness, shall not exceed 10.5 inches by 4.5 inches by 11 inches (H x W x D).

2.1.2 MATERIAL

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 top surface.

2.2 ELECTRONICS

2.2.1 MICROPROCESOR MONITOR

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 illuminate the DIAGNOSTIC indicator if a pulse is not received from the microprocessor within a defined period not to exceed 500 ms. Only an MMU(2) Power Failure shall reset the DIAGNOSTIC fault state of the monitor.

2.2.2 RMS VOLTAGE MEASUREMENT

High speed sampling techniques shall be used to determine the true RMS value of the AC field inputs. Each AC input shall be sampled a minimum of 32 times per line cycle. The RMS voltage measurement shall be insensitive to phase, frequency, and waveform distortion.

2.2.3 SOCKETS

In the interest of reliability, no IC sockets shall be used.

2.2.4 BATTERY

All user programmed configuration settings shall be stored in an electrically erasable programmable read-only memory (EEPROM). Designs using a battery to maintain configuration data shall not be acceptable. If a battery is used, it shall provide power only to the real time clock.

2.2.5 FIELD INPUT TERMINALS

All 120 VAC field terminal inputs shall provide an input impedance of at least 150K ohms and be terminated with a discrete resistor having a power dissipation rating of 0.5 Watts or greater.

2.2.6 COMPONENT TEMPERATURE RANGE

All electrical components used in the MMU(2) except the front panel Status LCD shall be rated by the component manufacturer to operate over the full NEMA temperature range of -34ºC to +74ºC.

2.2.7 PRINTED CIRCUIT BOARDS

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

a. Both sides of the printed circuit board shall be covered with a solder mask material.

b. The circuit reference designation for all components and the polarity of all capacitors and diodes shall be clearly marked adjacent to the component. Pin No. 1 for all integrated circuit packages shall be designated on both sides of all printed circuit boards.

c. All printed circuit board assemblies shall be coated on both sides with a clear moisture-proof and fungus-proof sealant.

2.3 FRONT PANEL AND CONNECTORS

2.3.1 MMU STATUS DISPLAY

A four line by 20 character alpha-numeric LCD display shall be provided to report MMU(2) status, time and date, menu navigation, etc. This display shall be separate from the full intersection channel status display.

2.3.2 FULL INTERSECTION CHANNEL STATUS DISPLAY

A separate Red, Yellow, and Green indicator shall be provided for the channel status LCD display for each channel to show full intersection status simultaneously. For Type 12 mode operation a separate Red, Yellow, Green and Walk indicator shall be provided for each channel to show full intersection status simultaneously. Individual icons shall also be provided to indicate channels involved in a fault.

2.3.3 LED DISPLAY INDICATORS

The following LED display indicators shall be provided:

2.3.3.1 POWER INDICATOR

The green POWER indicator shall flash at a rate of 2Hz when the AC LINE voltage is below the drop-out level. It shall illuminate steadily when the AC LINE voltage returns above the restore level. It shall extinguish when the AC Line voltage is less than 75 Vrms.

2.3.3.2 FAULT INDICATOR

The red FAULT indicator shall illuminate when the MMU(2) is in the fault mode and the OUTPUT relay has transferred to the Fault position.

2.3.3.3 PORT 1 RECEIVE INDICATOR

The yellow RECEIVE indicator shall illuminate for a 40 msec pulse each time a Port 1 message is

correctly received from the Controller Unit.

2.3.3.4 PORT 1 TRANSMIT INDICATOR

The yellow TRANSMIT indicator shall illuminate for a 40 msec pulse each time a Port 1 message is transmitted from the MMU(2).

2.3.3.5 COMM RECEIVE INDICATOR

The yellow COMM indicator shall illuminate for a 40 msec pulse each time a message is correctly received on the ECcom communications port (Ethernet or EIA-232).

2.3.3.6 DIAGNOSTIC INDICATOR

The red DIAGNOSTIC indicator shall illuminate when the MMU(2) has detected an internal diagnostic failure.

2.3.4 CONTROLS

All displays, controls, and connectors shall be mounted on the front panel of the MMU(2).

2.3.4.1 HELP BUTTON

A momentary contact button shall be provided the initiates the context sensitive help system described in 0.

2.3.5 MS CONNECTORS

The MS connectors on the MMU(2) shall have a metallic shell and be attached to the chassis internally. The connectors shall be mounted on the front of the unit in accordance with the following: Connector A shall mate with a MS 3116 22-55 SZ, and Connector B shall mate with a MS 3116 16-26 S.

In the interest of reliability and repair ability, printed circuit board mounted MS connectors shall not be acceptable. Internal MS harness wire shall be a minimum of No. 22 AWG, 19 strands.

2.3.6 ETHERNET PORT

An Ethernet port capable of a minimum 10 Mbps operation shall be provided on the front panel. The Ethernet port shall be electrically isolated from the MMU(2) electronics and shall provide a minimum of 1500 Vrms isolation. The connector shall be an RJ-45 eight pin connector.

2.4 MONITOR CONFIGURATION PARAMETERS

All NEMA standard configuration parameters shall be provided by a program card meeting the requirements of clause 4.3.6 of NEMA TS-2. All configuration parameters for functions and options beyond the requirements of the standard shall be stored in non-volatile memory within the MMU(2). This memory shall be programmable from the front panel menu driven interface, data downloaded via the ECcom port, or loaded from shadow memory located on the program card (see 0).

2.5 PROGRAM CARD MEMORY

The program card supplied with the MMU(2) shall provide non-volatile memory that contains the configuration parameters for the enhanced features of the MMU(2), such that transferring the program card to a different MMU(2) completely configures that MMU(2). The non-volatile memory device used on the program card shall not utilize any I/O pins designated as “Reserved” by NEMA TS-2.

3. EVENT LOGGING FUNCTIONS

3.1 GENERAL

The MMU(2) shall be capable of storing in non-volatile memory a minimum of 100 events. Each event shall be marked with the time and date of the event. These events shall consist of fault events, AC Line events, reset events, and configuration change events. The capability to assign a four digit identification number and 30 character description to the unit shall be provided. The event logs shall be uploaded to a

PC using the serial port of the MMU(2) and Windows based software provided by the manufacturer.

Each event log report shall contain the following information:

a) Monitor ID#: a four digit (0000-9999) ID number and 30 character description assigned to the monitor.
b) Time and Date: time and date of occurrence.
c) Event Number: identifies the record number in the log. Event #1 is the most recent event.

3.1.1 WAN NETWORK DISCOVERY

The communications software running on the PC shall be able to search the network and display a list of IP addresses and Monitor IDs of MMUs responding on the network. The communications software shall also be capable of making changes to the MMU(2) network parameters such as IP address and subnet mask.

3.1.2 ETHERNET PORT HTML INTERFACE

An HTML based capability shall be provided in the MMU(2) to configure the network parameters of the MMU(2) Ethernet port using a standard HTML browser.

3.2 REPORTS

3.2.1 MONITOR STATUS REPORT (CS)

The Current Status report shall contain the following information:

a) Fault Type: the fault type description.
b) Field Status: the current GYR(W) field status and field RMS voltages if the monitor is not in the fault state, or the latched field status and field RMS voltages and fault channel status at the time of the fault.
c) Cabinet Temperature: the current temperature if the monitor is not in the fault state, or the latched temperature at the time of the fault.
d) AC Line Voltage: the current AC Line voltage and frequency if the monitor is not in the fault state, or the AC Line voltage and frequency at the time of the fault.
e) Control Input Status: the current state and RMS voltages of the Red Enable input & Load Switch Flash bit input if the monitor is not in the fault state, or the status latched at the time of the fault.

3.2.2 PREVIOUS FAULT LOG (PF)

The Previous Fault log shall contain the following information:

a) Fault Type: the fault type description.
b) Field Status: the latched field status with RMS voltages, fault channel status, RP Detect status and Field Check status at the time of the fault.
c) Cabinet Temperature: the latched temperature at the time of the fault.
d) AC Line Voltage: the AC Line voltage & frequency at the time of the fault.
e) Control Input Status: the latched state of the Red Enable input at the time of the fault.

3.2.3 AC LINE EVENT LOG (AC)

The AC Line log shall contain the following information:

a) Event Type: describes the type of AC Line event that occurred.
   Power-up - AC on, monitor performed a cold start
   Interrupt - AC Line < Brownout level
   Restore - AC restored from AC brown-out or AC interruption (AC Off), no cold start
b) AC Line Voltage: the AC Line voltage & frequency at the time of the event.

3.2.4 MONITOR RESET LOG (MR)

The Monitor Reset log shall contain the following information:

a) The monitor was reset from a fault by the front panel Reset button, or External Reset input, or a non-latched event clear.

3.2.5 CONFIGURATION CHANGE LOG (CF)

The Configuration Change log shall contain the following information:

a) The status of all configuration programming including the contents of the Program Card.
b) Any configuration programming inputs such as 24V Inhibit, Port 1 Disable, Type Select.
c) Configuration Check Value: A unique check value that is based on the configuration of items #a and #b above.

The log shall also indicate which items have been changed since the last log entry.

3.2.6 SIGNAL SEQUENCE LOG (SSQ)

A minimum of five logs shall be provided that graphically display all field signal states and Red Enable for up to 30 seconds prior to the current fault trigger event. The resolution of the display shall be at least 50 milliseconds.

3.3 REMOTE MONITOR CONFIGURATION

3.3.1 SETUP WIZARD

A setup mode shall be provided by the Windows based software that automatically configures the Dual Indication enable, Field Check enable, Red Fail enable, and Minimum Yellow Plus Red Clearance enable parameters from user input consisting only of channel assignment and class (vehicle, ped, pp-turn, FYA, etc.) responses.

3.3.2 UPLOAD FROM FILE

All configuration parameters for functions and options beyond the requirements of the standard shall be programmable by transferring a file from a PC to the MMU(2) via the front panel Ethernet port. These parameters shall be stored in nonvolatile memory in the MMU(2).

3.3.3 DOWNLOAD TO FILE

All configuration parameters for functions and options beyond the requirements of the standard shall be downloadable to a PC by transferring a file from the MMU(2) to a PC via the front panel Ethernet port.

C. TS2 TYPE 1 CABINET ASSEMBLY

1.0 GENERAL

This specification 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. TS2-2003. Where differences occur, this specification shall govern. The controller cabinet shall meet the following functional requirements:

2.0 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 outside. 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 four 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 inch 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 inches 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 150 degrees under windy conditions.

The main door shall be equipped with a Corbin tumbler lock No. 2. Two keys shall be supplied. The police door-in-door shall be provided with a treasury type lock Corbin No. 2 or exact equivalent and one key.

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 front side of the cabinet door. A 1/2 inch expansion material shall be installed between the cabinet base and the concrete pad.

3.0 TERMINALS AND FACILITIES/MAIN PANEL DESIGN AND CONSTRUCTION

The main panel shall be constructed from 5052-H32 brushed aluminum of 0.125 inches minimum thickness and formed so as to eliminate any flexing when plug-in components are installed.

All four, eight, 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:

a. 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.
b. Type 2 Configuration - Eight load switch sockets, four flash transfer relay sockets, one flasher socket and two main panel BIU rack positions.
c. Type 3 Configuration - Twelve load switch sockets, six flash transfer relay sockets, one flasher socket and two main panel BIU rack slots.
d. 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 sixteen-load switch sockets positioned horizontally.

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.

Load switch outputs shall be routed to terminals on a series of 12 position screw terminal blocks in one row for all sixteen load switcher.

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-Silkscreen. All Silkscreen shall use standard nomenclature per the NEMA TS2 specification. Each signal output channel on the loadbay shall incorporate a removable and hot-pluggable module providing capacitive loading if required, and MOV protection. MOV protection shall be provided for each output. Capacitive loading shall be available for each output or for green and yellow outputs only. Capacitive loading shall provide an AC impedance equivalent to the DC resistance provided by a 1.5 K-ohm resistor. Modules shall be accessible from the front of the loadbay and easily replaceable, at the field terminals. This is to provide surge protection.

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 (or metric equivalent) screw as minimum. Functions to be terminated shall be as specified in the listing of Input/Output Terminals in the TS2-2003 Standard document (Section 5).

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

-	Green/Walk load switch output	green 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, for greens and yellows)	blue wire 22 gauge
-	MMU (other than AC power, for reds)	yellow 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 inches thick PVC insulation with clear nylon jacket and rated to 105 degrees Celsius. All 12 AWG and larger wire shall have UL listed THHN/THWN 90°C, 600V, 0.020 inches 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 tie wrapping.

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 (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.

4.0 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 panel shall be protected with a removable clear plastic front cover which forms a 90 degree lip at the top whereby prevents falling objects from making accidental contact with the electrical components of the power panel. The cover shall be secured with three bolts using threaded thumb screw design nuts. Two spare thumb screw nuts shall be provided in the cabinet drawer. The cover shall be constructed to

permit the operation of the main and auxiliary breakers without removing the cover.

The power panel shall house the following components:

a) 16 position cabinets shall have 30 amp breaker. 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.
b) A 15 amp auxiliary breaker. This breaker shall supply power to the fan, light and GFI outlet.
c) A 15-amp breaker shall supply power to the cabinet flasher.
d) A 15-amp breaker shall be labeled as “SPARE”.
e) A 115V/75A Crydom A-2475 solid state contactor or equivalent shall be used instead of a mercury contactor.
f) A neutral bus bar capable of connecting one No. 6 stranded wire in each position with a minimum of 15 positions.

5.0 AUXILIARY CABINET EQUIPMENT

The cabinet shall be provided with a thermostatically controlled (adjustable between 27°C and 66°C) 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.

LED light panels shall be mounted on the inside top of the cabinet and on the bottom side of the bottom cabinet shelf. The LED light panels shall be 15W to 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 an 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 permanent graphics identification template with a minimum dimension of 9 inches by 11 inches shall be inked, transferred, or silk screened using permanent ink or equal on a material comparable to the 3M product 160-130TPF Control Tac film and shall be attached to the inside of the cabinet door. The graphic 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.

6.0 VEHICLE DETECTION

See Section G for vehicle detection system specifications. All signal cabinet equipment specified or required by the manufacturer of the vehicle detection system shall be installed.

6.1 DETECTOR RACKS

When required by the vehicle detection system, a vehicle detector amplifier rack shall be provided in each cabinet. The configuration for each rack shall be as follows:

a) One (1) BIU slot.

b) Sixteen channels of NEMA TS2 type detection (2- and 4-channel detector cards).
c) Two optical preemption slots, 2-channel or one 4-channel phase selector unit.

The detector rack shall, as a minimum, meet the requirements of all applicable sections of the NEMA Standards Publication No. TS2-2003 v02.06 Traffic Controller Assemblies.

The detector rack frame shall be constructed of aluminum. The frame material shall be of sufficient thickness to prevent bending or flexing when detector or other cards are inserted or removed.

All vehicle detector card slots shall be capable of accepting 2-channel detector cards.

The second, fourth, sixth and eighth vehicle detector card slots shall be capable of accepting both 2- and 4-channel detector cards.

Pristine circuit boards shall be used in the construction of the detector rack. No hand wired jumpers to connect or re-route PCB traces shall be allowed.

6.2 FIELD LOOP INTERFACE PANEL

One 16 channel field loop interface panel shall be mounted on the left wall of the cabinet and connected to the card rack and back pane.

The panel shall be constructed of aluminum, silk-screened, and contain two 16-position terminal blocks, with minimum 8-32 binder head screws for loop termination.

Provisions shall be made to terminate eight pedestrian push button inputs, and appropriate power connections.

Terminals shall also be provided for detector outputs. When logic ground is applied to these terminals a call shall be placed via the BIU on the proper controller channel.

The panel shall contain 16 technician operated vehicle detection switches meeting the following criteria:
- Up Position – Holding call (labeled “CALL”)
- Middle Position – No call (labeled “AUTO”)
- Down Position – Momentary call (labeled “TEST”

The panel shall contain eight technician operated pedestrian switches meeting the following criteria:
- Up Position – Holding call (labeled “CALL”)
- Middle Position – No call (labeled “AUTO”)
- Down Position – Momentary call (labeled “TEST”

All terminals shall be silkscreen as to designate function on both the front and rear of the panel.

7.0 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:

a. AUTO/FLASH SWITCH. When in the flash position, power shall be maintained to the controller and the vehicular signal heads shall display the programmed flashing red or amber indications generated by the flasher unit. Pedestrian indications, if any, shall be dark. The controller shall not be stop timed when in flash. The MMU shall not be used to accomplish this task. When placed in the “NORM” position, the vehicular and pedestrian signal heads shall resort to the controller’s programmed operation. This will force the controller to initiate the startup sequence when exiting flash.
b. STOP TIME SWITCH. This switch shall apply stop time to the Controller via the main

back panel. When in the “ON” position the Controller will enter stop time operation. When placed in the “OFF” position the Controller shall resort to normal operation.

c. CONTROL EQUIPMENT POWER ON/OFF. This switch shall control the AC voltage supplied to the Controller, MMU, and the cabinet Power Supply. When placed in the “OFF” position voltage shall be removed from the listed equipment. When placed in the “ON” position voltage shall be supplied to the listed equipment.

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:

a. SIGNALS ON/OFF SWITCH. This switch shall control all AC voltage to the vehicular and pedestrian signal head displays. When placed in the “ON” position AC power is supplied to the field indications. 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.
b. EMERGENCY FLASH MODE SWITCH LABELED AUTO/FLASH. When placed in the “FLASH” position the vehicular signal heads shall display the programmed flashing red or amber indications generated by the flasher unit. Pedestrian indications, if any, shall be dark. Power shall not be removed from the controller. Stop time shall be applied. When placed in the “AUTO” position, the controller shall initiate the start-up sequence and enter the normal controller operating parameters.
c. 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.

8.0 SWITCHES – GENERAL

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.

9.0 CONTROLLER TELEMETRY INTERFACE PANEL

A panel shall be provided for railroad preemption interface terminals. The panel shall be located on the inside left wall of the cabinet.

The railroad preempt interface panel shall provide six momentary push-button test switches for preempts 1, 2, 3, 4, 5 and 6.

The railroad preempt interface panel shall provide a switch labeled “Free / System” to set the controller to manual free operation.

The panel shall also provide six SDLC cables to service two terminal facility (back panel) BIU’s, the TS2 controller, one detector racks and Malfunction Management Unit (MMU). The SDLC cables shall attach to the panel. One of the six SDLC cables shall be coiled and attached to the panel as spares.

There shall be a ten position terminal block for termination of optical preemption field connections. This shall be connected to the main preempt 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 "DB" 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 ten position EDCO PCB- 1 B or exact equal 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.

A socket mounted communication line transient protection device shall be supplied with the telemetry interface panel. The device shall be an EDCO model PC642C008D or exact approved equivalent. The transient protection device shall be wired in series with the telemetry communication circuit.

10.0 AUXILIARY DEVICES

10.1 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.

10.2 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.

10.3 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.

10.4 MALFUNCTION MANAGEMENT UNITS

Each cabinet assembly shall be supplied with one Malfunction Management Unit (MMU). The MMU shall

meet all specifications of the NEMA Standard TS2-2003 (R2008) for the MMU2 configuration while maintaining compatibility with NEMA TS1-1989 Assemblies. Malfunction Management Units shall provide an Ethernet interface for system communications and status.

Malfunction Management Units shall be a Type 16. The MMU shall be an EDI Model MMU2- 16LEip, or equivalent.

10.5 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.

10.6 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 NEMA TS2 power supply shall be supplied with each cabinet assembly.

10.7 ETHERNET SWITCH

Each cabinet shall be equipped with a minimum eight port managed Ethernet switch. The Ethernet switch shall be NEMA TS-2 rated. The switch will have at least six 10/100 Ethernet ports and two Single Mode Fiber ports. SFP’s shall be 1000BASE-LX. The switch shall be powered by AC line voltage. The Ethernet switch shall be fully compatible with the City’s existing Traffic Signal network.

Patch cables to provide functional connection of the Ethernet switch to the Fiber Optic distribution panel and to the signal controller shall be provided.

11.0 TESTING AND WARRANTY

11.1 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.

11.2 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 1 year.

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

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, such as EDCO Model ACP 340 surge protectors, as a minimum. 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, etc. Duplex outlets, which are provided for equipment such as modems and other low current auxiliary equipment, shall 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 eight by twenty microsecond wave shape; have a life test with a maximum of a five percent 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°C to +85°C. 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 two pole, weather tight circuit breaker type disconnect. The unit shall be rated a minimum of 60 amps and grounded as per NEC standards.

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)

1.0 GENERAL

This specification establishes the minimum requirements for a complete emergency battery back-up system for use at traffic signals utilizing Light Emitting Diodes (LED) signals and pedestrian heads. The Battery Back-up System (BBS) shall include, but not be limited to the following:

- BBS with Inverter, Charger, Tap Switching Transformer and Internal Power Transfer Switch.
- Automatic and Manual Bypass Transfer Switch units.
- Batteries
- Cabinet
- Wiring

The BBS shall provide reliable emergency power to a traffic signal in the event of a power failure or interruption.

The BBS will be the most current version of the FXM 1100 rugged UPS module, Alphacell 195 XTV batteries (four), SE48-2216 general purpose outdoor traffic enclosure (modified with internal sliding shelves), Universal Automatic Transfer Switch, Universal Generator Transfer Switch, and all supplemental equipment. Equivalent BBS hardware may be approved by the City Traffic Engineer. The BBS shall be fully compatible with the City of Council Bluffs' existing BBS infrastructure

2.0 OPERATION

2.1 GENERAL

The BBS shall provide the following operational modes when operating on battery power:

- Full operation of all traffic signal devices
- Flash operation
- Combination of full and flash operation

2.2 RUN TIME

The BBS shall provide a minimum of 8.0 hours of full-time operation with a 450 watt load @ 25°C. The minimum battery size requirement is listed in section 8.0, Battery Type.

2.3 COMPATIBILITY

The BBS shall be compatible with Model 30X, 33X, and 34X cabinets; the ITS cabinet; model 170 and 2070 controllers and any NEMA style cabinet, enclosures and controllers; the Advanced Transportation Controller; and all cabinet components for full time or flash operation.

2.4 OUTPUT CAPACITY

The BBS shall be rated at a minimum of 1100W/1100VA@25°C active output capacity with 82 percent minimum inverter efficiency with 30% minimum loading.

2.5 OUTPUT VOLTAGE

When operating in backup mode, the BBS output shall be 120VAC ± 2%, pure sine wave output, ≤3%THD, 60Hz ± 5%.

2.6 DC SYSTEM VOLTAGE

The BBS DC system voltage shall be 48VDC nominal.

2.7 TRANSFER TIME

The maximum transfer time allowed, from disruption of normal utility line voltage to stabilized inverter line voltage from batteries, shall be 5 milliseconds (ms). The same maximum allowable time shall also apply when switching from the inverter line voltage to utility line voltage after the line has been qualified. Transfers to and from battery operation shall not interfere with the operation of the other equipment in the intersection.

2.8 LINE QUALIFY TIME

The BBS shall have a user definable line qualify time. The user shall be able to set a time within the range of 3s-999s. The default line qualify time shall be 3 seconds.

2.9 OPERATING TEMPERATURE

The BBS and all components shall operate without performance degradation over a temperature range of -40°F to +165°F with a maximum load of 70% of rated output of the BBS inverter.

2.10 FEEDBACK LEVEL

The BBS shall be tested and certified to Electrical Standards UL 1778 and CSA 107.3.

2.11 SURGE PROTECTION

The BBS shall have surge protection compliant with IEEE/ANSI C.62.41 Cat. A & B.

2.12 POWER AND CONTROL CONNECTIONS

The BBS shall be easily installed, replaced, or removed by using easily removable cables for AC input, AC output, DC input, and battery temperature sense.

2.12.1 AC CONNECTION

The AC input and output hardwired connections shall be separate 3-position euro style terminal blocks mounted on a rotatable panel as part of the front of the BBS.

2.12.2 DC CONNECTION

The DC connection shall be a recessed one-piece Gray Anderson style connector rated to handle the maximum DC current required by the inverter while running on batteries.

2.12.3 TEMPERATURE PROBE CONNECTION

The battery temperature sense inputs shall be panel-mounted Telco style connector.

2.13 AC INPUT CIRCUIT BREAKER

The BBS shall be equipped with a flush mounted AC Input circuit breaker that protects both the BBS and the loads connected to the output. Should the AC Input breaker on the BBS trip, it shall allow the BBS to go to inverter mode to power the intersection off batteries. Should an overload condition still exist when the inverter is energized the inverter will revert to its internal electronic protection, preventing damage to the inverter due to the overload or short circuit condition, on the output.

2.14 AC OUTPUT CIRCUIT BREAKER

The BBS shall not have an AC Output circuit breaker or combination Input/Output breaker. An AC output breaker prevents the inverter from powering the load from batteries when tripped.

2.15 BATTERY CIRCUIT BREAKER

The BBS shall have a flush mounted Battery circuit breaker installed on the front panel of the BBS inverter module.

2.16 OVERLOAD

The BBS Inverter Module must be able to shut down in order to protect against internal damage in the event of an overload at the output. The Inverter shall support an overload up to 110% for 2 minutes and then turn off the inverter output. The fault recovers when the overload is removed and line power returns. There shall not be an AC output circuit breaker.

2.17 AC FEEDBACK

The BBS shall prevent a malfunction feedback to the cabinet or from feeding back to the utility service.

2.18 BBS FAILURE MODE

In the event of BBS failure (inverter/charger or battery) or complete battery discharge, the internal power transfer relay shall revert to Normally Closed (de-energized) state and provide utility power to the intersection when utility line power is available to the cabinet.

2.19 AUTOMATIC SHUTDOWN

The BBS shall initiate an automatic shutdown when battery output reaches 42.0VDC.

2.20 DESTRUCTIVE DISCHARGE OR OVERCHARGE

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

2.21 BATTERY TEST

The BBS Inverter Module shall be programmable to perform automatic battery tests at user defined intervals to meet specific requirements or manufacturer’s recommendation.

- Intervals are set in days between tests
- Programmable start hour
- Programmable test timeout range 6 minutes to 10 days 10 hours
- Programmable test termination voltage
- Web browser to show battery test time remaining, elapsed time, error condition, last test

completed date/time, and days until next test
- During self-test the BBS Inverter Module shall identify a weak battery string and initiate an Alarm.

2.22 SCHEDULER – TIME OF DAY SCHEDULE (TOD)

The BBS shall provide a scheduler with settings programmable by the user.
- The scheduler shall allow the user to program at least five time spans with start and end times
- Each time span shall be selectable as to whether it is applicable All Days, Weekdays, or Weekends
- The scheduler shall allow the user to schedule operational modes as required, per intersection.
- A dry contact relay shall be programmable to use a programmed time span to prevent a relay from being energized during the time span

2.23 BATTERY STATE OF HEALTH (SOH)

The SOH is a percentage estimate of the state of health of the battery. The BBS shall show the approximate SOH of the battery when discharges of greater than 20% are done during a battery test.

2.24 USER CONFIGURABLE ALARMS

The BBS shall have at least 70 user configurable alarms. Each alarm shall be configurable as to:
- Enabled or Disabled
- Alarm Priority levels – Settable to Warning, Minor, Major, and Critical
- Parameter – Customizable user value for filtering
- Custom Name
- Dry Contact Relay – User can select which relay will be controlled by the alarm

2.24.1 ALARM CUT-OFF

If an alarm is triggered the user can select the alarm window and click, “Alarm Cut-Off” to cut off the alarm for the set period and the system will show the alarm(s) as “Acknowledged” and deactivate any assigned relays.

2.24.2 COLOR SEVERITY

The alarm window background on the LCD and web browser interface shall be color coded with the highest active alarm severity level:
- LCD – No Alarms/Warning = Green, Minor = Yellow, Major/Critical = Red
- Web – No Alarms/Warning = Blue, Minor = Orange, Major/Critical = Red

2.25 CUSTOM DATA AND CUSTOM ACTIONS

The BBS shall have the ability to capture custom data by either numeric or state value. These values can then be used in user created formulas to produce a numeric or Boolean output. The output can be used for reporting or for controlling dry contact relays by creating Custom Actions. In addition, counters and timers can be created to further custom data and actions.
- Counters – An Up or Down counter can be created to count how many times an event has happened and drive a custom action.
- Timers - The Delay Timer can be used with Custom Data to produce a programmable delay when a certain event happens. The Interval Timer can be used with Custom data to measure the time between two events.

2.26 OPTIONAL ANALOG DIGITAL INPUT OUTPUT (ADIO) DEVICE

An optional ADIO device can be connected to the BBS for external control of devices via additional dry contact relays or for monitoring current, DC volts, temperature, and digital input (contact closure). The ADIO communicates with the BBS via the CAN bus.

3.0 AUTOMATIC VOLTAGE REGULATION (AVR) – BUCK/BOOST

3.1 AVR

The BBS shall include AVR (Auto Voltage Regulation) Functionality. The BBS shall be Double Buck/Double Boost (two steps of each) – Line-Interactive, True BBS.

- The Double Buck/Double Boost mode shall have a minimum input range of 85 - 171 VAC.
- There shall not be any user definable transfer set points for the buck or boost modes.
- Whenever AVR mode is selected, the output of the system shall be regulated between 108-130VAC. When the output of the system can no longer be maintained with this range, the BBS shall transfer to Inverter or Backup Mode.

4.0 BATTERY CHARGER

4.1 BATTERY CHARGER

The BBS shall have an integral three stage charger that is compatible with Gel and AGM battery topology. The charger shall be an intelligent charger with control systems that automatically incorporates bulk, absorption and float charging modes. Two stage chargers are not allowed.

The integral intelligent charger shall use temperature compensation. The charging system shall compensate over a range of -55.6 - 0.0mV/°F/Cell, user adjustable when required. Default setting shall be -1.4 mV/°F/Cell. Temperature compensation shall occur during absorption and float modes.

A temperature probe which plugs into the front panel of the BBS shall be used to monitor the internal temperature of the batteries. The Temperature sensor shall be 6.5 feet in length, external to the inverter/charger module and have a 3/8 inc lug for attaching to the negative terminal of the battery string.

If the temperature probe fails or is not connected to the BBS, the charger shall still charge the batteries but to a maximum of 52.5VDC.

The batteries shall not be recharged whenever the battery temperature exceeds 122°F.

The recharge time for the batteries from “protective low-cutoff” to 80% or more of full charge capacity shall not exceed 8 hours if the charger is set to maximum. The BBS charger shall be capable of providing 15 amps at 54VDC depending on load.

5.0 USER INTERFACES AND DISPLAYS

5.1 INVERTER/CHARGER DISPLAY

The BBS inverter/charger unit shall include a 4.3 inch backlit LCD Touchscreen display for viewing all status and configuration information. The screen shall be easily viewable in both bright sunlight and in darkness. The screen assembly shall be rotatable.

5.2 LCD SCREEN LAYOUT

The screen shall have different sections that contain:

- System Status Dashboard – Shows six I/O values or configuration
    - Dashboard Paging – Allows navigation to all four user configurable System Status panels
        - Total of 24 user configurable System Status fields displayed
- Alarms – Shows highest level active alarm. Color coded based on severity. Touching takes user to see all active alarms and allows for alarm cutoff

- Maintenance – Access to alarm cutoff, battery testing, and relay testing
- Information – Access to serial number and software and OS version
- Menu – Access to all controller menus
- Shortcuts – Access to most often used areas
- Login/Logout – For permissions to edit settings

At a minimum the LCD screen and web pages can show any of the following active real time readings and information:

- Operating mode (Line, Standby, Backup, Buck / Boost)
- Utility input voltage
- BBS output voltage and current
- Battery voltage, Temperature, SOH, SOC
- Input Frequency
- Output Power
- Charger Voltage, Current, Mode
- Battery mode
- Timer Relays delay remaining
- IP Address
- Accumulated output power in kW hours
- Battery Runtime Remaining
- Unit Serial number
- Unit Firmware Version
- Any alarms

The Menu shortcut layout shall follow the web browser interface menu navigation and allow for full programmability of the BBS.

5.3 WEB BROWSER INTERFACE

The BBS shall be provided with an embedded web server for user configuration and management through a web browser without needing to install computer software.

5.3.1 QUICK STATUS AREA

The quick status area shall remain at the top of all pages and show any active alarms and the first six fields of the LCD dashboard along with Battery Voltage and Battery Current. It shall also include a search field to aid the user in quickly finding the item they are looking for.

5.3.2 MENUS

The menu system shall include the following menu sections and abilities:

- Dashboard – Controller and BBS Status
- Power Flow – See 5.3.3
- Controller – Comm setup, NTP, Users & Security, Scheduler for TOD
- System – BBS Status and Configuration
- Modules – BBS Firmware upgrades
- Alarms – Configure Alarms
- Logs – Events, Alerts, Battery, Power Outage, Datalogs, and Performance Logs

5.3.3 POWER FLOW

There shall be a live Power Flow diagram that shows the active flow of power with values from the AC Source, Input Circuit Breaker, BBS, Load, Battery Breaker, and Battery. The BBS section shall show any active dry contact relays and alarms. The battery shall show any active alarms.

5.3.4 MINIMUM CAPABILITIES

The BBS shall allow the user to do the following through the web browser:

- View logs
- Configure network parameters
- Configure email
- Adjust line qualify time
- Configure dry contact relays
- Configure alarms
- Configure Time/Date, NTP
- Configure communications
- Configure users and security
- Controller and BBS firmware to be upgradeable remotely via Ethernet

5.4 STATUS LEDs

The BBS shall have discrete status LED indications on the front of the inverter/charger.

- Green Output LED shall be Solid ON any time that the output of the BBS is in Line or AVR (Buck/Boost) modes. When the BBS output is in Backup (Inverter) Mode the LED will flash On and Off.
- Red LED shall be Solid On any time there is one or more major or critical active alarms
- Yellow LED shall be Solid On any time there is one or more minor active alarms

5.5 LOGS – EVENT, ALERTS, BATTERY, AND POWER OUTAGE LOGS

5.5.1 EVENT LOG

The BBS shall maintain an event log containing a minimum of 3000 of the most recent events. The event log shall be downloadable as a csv file by web browser and exportable by USB port on the BBS. The log shall be date and time stamped. The most recent 300 events of the log shall be viewable by web browser and 25 by LCD. The event log shall capture:

- BBS System Mode
- AC Power Outage
- Configuration Changes
- Battery Mode
- Dry Contact Relay Status
- User Logon
- Firmware Updates
- Web Sessions

5.5.2 ALERT LOG

The BBS shall maintain an alert log containing a minimum of 3000 of the most recent events stored in a ‘first in first out’ (FIFO) buffer. The alert log shall be downloadable as a csv file by web browser and exportable by USB port on the BBS. The log shall be date and time stamped. The most recent 300 events of the log shall be viewable by web browser and 25 by LCD. The alert log shall capture all alarms.

5.5.3 BATTERY LOG

The BBS shall maintain a battery log containing a minimum of 3000 of the most recent events stored in a ‘first in first out’ (FIFO) buffer. The battery log shall be downloadable as a csv file by web browser and exportable by USB port on the BBS. The log shall be date and time stamped. The most recent 300 events of the log shall be viewable by web browser and 25 by LCD. The battery log shall capture:

- Duration

- Battery capacity
- Ah delivered
- Charge in SOC%
- Starting SOH%
- Change in SOH%
- Battery current average

5.5.4 POWER OUTAGE LOG

The BBS shall maintain a power outage log containing a minimum of 3000 of the most recent events stored in a 'first in first out' (FIFO) buffer. The battery log shall be downloadable as a csv file by web browser and exportable by USB port on the BBS. The log shall be date and time stamped. The most recent 300 events of the log shall be viewable by web browser and 25 by LCD. The power outage log shall capture Start Time, End Time, and Duration.

5.5.5 DATA LOGS

The BBS shall be capable of recording up to ten data logs each with up to 20 data signals. The data logs shall be downloadable as a csv file by web browser and exportable by USB port on the BBS. User can configure the interval between the samples within a range of 2 seconds to 3 hours. User can configure the number of samples to capture from a range of 60-3600. When the maximum number of samples has been captured the newest sample replaces the oldest. Data capture can run continuously or be triggered by an equation. The BBS shall create a preview chart that shows continuous feed of data of up to 30 samples, FIFO, viewable on web browser only.

5.5.6 PERFORMANCE LOGS
The BBS shall have pre-configured performance logs that run continuously and automatically, viewable on a web browser. There shall be separate charts for Seconds, Minutes, Hours, and Days that shows the Average, Minimum, and Maximum values for each sample. A daily log that has the Average, Minimum, and Maximum values shall be logged and be downloadable as a csv file by web browser. The signals to be monitored are:

- Controller Memory in Use
- CPU Usage
- AC Output Voltage
- Battery Current
- AC Output Current
- Battery Voltage
- AC Output Voltage
- AC Output Apparent Power

5.6 COUNTERS

The BBS shall keep track of the following:

- The number of times that the unit was in Inverter, Buck, and Boost, logged separately since the last reset.
- The accumulated number of hours and minutes that the unit has operated in Inverter, Buck, and Boost, logged separately since the last reset.
- The total power consumed by the load in kWh.

5.7 PROGRAMMABLE RELAY CONTACTS

The BBS shall provide the user six dry relay contacts. Five programmable and one 48VDC relay contact. As a minimum, the programmable options shall be On Battery, Low Battery + No Line, Timer, and Alarms. The BBS shall also have three input contacts pre-programmed for Battery Test, User Alarm, and AC Shutdown.

Relays C1-C5 shall be able to be triggered/driven by more than one condition. Relays C1-C5 shall be able to have their default state programmed to be energized (NO contacts closed) when not triggered/driven.

The relay contacts shall be made available on the front panel of the BBS via six 3-position plug-in terminal blocks with screw down wiring connections.

Each relay, C1 through C6 shall have their own common and their own set of normally open (NO) and normally closed (NC) terminals. The terminals for each relay shall be oriented as NO-C-NC on the terminal block. C6 shall provide continuous 48 VDC voltage for powering of enclosure DC fan.

The contacts on the terminal block shall be labeled 1-18, left to right. Additionally, each set of contact shall be labeled with the NO-C-NC designation, as well as C1…C6 from left to right. Printed labels noting all alarms and faults shall be provided with the BBS Inverter/Charger to be installed when required.

The relay contacts shall be rated at a minimum of 1 amp @ 250 VAC.

5.7.1 ON BATTERY RELAY CONTACT

The dry relay contacts that are configured for “On Battery” shall only energize when the BBS is operating in Inverter Mode.

5.7.2 TIME RELAY CONTACTS

The BBS shall include timers that will energize the associated “Timer” dry relay contact after the user configured time has elapsed when the BBS is in Inverter mode. The timer is started when the BBS enters Inverter Mode. The user shall be able to configure the timer to the required time. The timer shall have an adjustable range of 0-720 minutes. The user shall be able to create at least ten user settable timers.

5.7.3 LOW BATTERY + NO LINE RELAY CONTACT

The BBS shall have an adjustable low battery relay setting. This setting shall be adjustable so that the user can set the point at which the low battery relay contact is energized. The low battery setting shall be adjustable from 0 to 100%. Once energized, the Low Battery + No Line relay shall de-energize as soon as line power has been restored and qualified.

5.8 USER INPUT CONTACTS

The BBS shall have three optically isolated, programmable user input contacts. The user input contacts shall be able to be programmed for Self-Test Start, User Alarm, and UPS Shutdown.

5.9 PROBE JACKS

The BBS shall provide voltmeter standard probe input-jacks (+) and (-) to read the exact battery voltage at the inverter input.

6.0 COMMUNICATION

6.1 ETHERNET INTERFACE

The BBS shall have two internal Ethernet communication interface ports for user configuration and management. One of the ports shall be static with a manufacturer set IP address of 192.168.0.90 and the other port set to DHCP. The Ethernet Ports shall be an RJ-45, EIA 568B Pin Out Connector.

- The BBS shall include remote monitoring & alarms transmission capabilities through the Ethernet RJ-45 IP Addressable Port, using SNMP v3 protocol.
- System shall have the capability of notifying Operations, Maintenance or TMC via e-mail of any alarms, user selectable.
- Emails are to be held in a batch and released after the configured interval has elapsed. Interval can be set from 5 to 60 minutes. Interval timer starts after first alarm trigger. Email to include:
    - Subject line with filterable text and alarm counts
    - Static title for filtering
    - Configurable name of the controller
    - A Google map link to location (if setup)
    - Time and date of notification
    - List up to ten active alarms, sorted by priority with an active alarm count indicator showing total active alarms
    - List up to ten cleared alarms, sorted by priority with a cleared alarm count indicator showing total cleared alarms
- All BBS configuration menus shall be accessible and programmable from the Ethernet Port.
- The BBS shall support TCP, UDP, and HTTP over IP protocol communications.

6.1.1 USER ACCOUNTS

The BBS shall have seven user accounts: one administrator, one account manager and five operators. Each account shall have five different User Roles that could be assigned to it: administrator, account manager, operator, restricted operator, and guest, each with different permission levels.

6.1.2 PASSWORDS

Password length shall be up to 32 characters (256 bit)

6.2 INTEGRATED USB HOST – USB TYPE A

The BBS shall have a USB Type A connector for firmware upgrades and file management. The USB shall support:

- Exporting and importing BBS configuration to copy configuration to other units
- Exporting log files
- Firmware and software upgrades
- Mouse and Keyboard input

6.3 SERIAL – USB TYPE MINI B

The BBS shall have a USB Type Mini B connector for soft shutdown of MegaTec protocol compliant client.

6.4 CAN

The BBS shall have an RJ12 connector for CAN bus communications to ADIO interfaces and other devices.

6.5 TIME/DATE

SNTP (Simple Network Time Protocol) - The BBS shall have the ability to synchronize with a network or internet-based time server.

The BBS shall have the ability to synchronize to web browser.

Daylight Savings – The user shall be able to choose Standard Time, US/Can Daylight Savings, or

always Daylight Savings.

7.0 AUTOMATIC BYPASS TRANSFER SWITCH

7.1 RATING

The BBS shall include a rack mounted Automatic/Manual Transfer Relay rated at 120VAC/30 amps.

7.2 AUTOMATIC & MANUAL BYPASS SWITCH

The Automatic Bypass Transfer Switch shall be a combination automatic/manual bypass switch. Placing the bypass switch in the “Bypass” mode shall transfer the intersection load from the BBS output directly to commercial power. AC commercial power must still be available to the BBS input, allowing the BBS to keep the batteries charged. A UPS Supply Breaker shall be provided and located on the Bypass Switch, which allows the user to be able to manually shut off commercial power to the UPS input, allowing them to safely disconnect and remove the inverter. With the inverter turned off, the batteries can be safely disconnected from the system.

7.3 INDICATOR LIGHT

The Automatic Bypass Transfer Switch shall include a bypass indicator light that automatically notifies the user when the Manual bypass switch is in Bypass position. The indicator light shall be illuminated when in UPS mode.

7.4 INTEGRATED SWITCH

The manual bypass switch and the automatic transfer relay shall be integrated together within the Automatic Bypass Transfer Switch allowing the manual bypass switch to be rated at 10 Amps and to be integrated with the bypass indicator light.

7.5 TERMINAL BLOCKS

The Automatic Bypass Transfer Switch shall have terminal blocks capable of accepting No. 6 AWG wiring for the AC input and output with #10 AWG from the Automatic Bypass Transfer Switch to inverter/charger module.

8.0 AUTOMATIC GENERATOR TRANSFER SWITCH

8.1 RATING

The BBS cabinet shall include a rack mounted Automatic Generator Transfer Switch rated at 120VAC/30 amps.

8.2 AUTOMATIC & MANUAL GENERATOR TRANSFER

The Automatic Generator Transfer Switch shall be a combination automatic/manual generator switch. Placing the generator switch in the “Line” mode shall pass the utility power from the Line Input to Line Output. With the switch in “Gen” mode the transfer switch will automatically disconnect the utility and connect generator power to Line Output when the generator input voltage is approximately 102VAC or greater.

9.0 BATTERIES

9.1 BATTERY TYPE

The battery shall be virgin lead alloy, calcium based, extreme temperature, float cycle, AGM (Absorbed

Glass Mat) VRLA (Valve Regulated Lead Acid). Batteries designed for Cycle applications, such as Solar or deep cycle, are not acceptable. The battery must be designed for Standby BBS applications. Individual batteries shall meet the following specifications:

- Voltage Rating: 12V
- Amp-hour rating: 100 Ah, at the 20 hour rate, to 1.75 Volts per cell, minimum battery rating.
- Group size: Case 27
- Batteries shall be easily replaced and commercially available off the shelf.
- Batteries shall provide 100% runtime capacity out-of-box. Each battery must meet its specification without the requirement of cycling upon initial installation and after the initial 24 hour top off charge.

9.2 BATTERY STRING

Batteries used for the BBS shall consist of four batteries configured for a 48 VDC battery buss system.

9.3 OPERATING TEMPERATURE

Batteries shall be certified to operate at extreme temperatures from –40°C to +60°C.

9.4 HANDLE

An integral lifting handle shall be provided on the batteries for ease of removal/installation.

9.5 BATTERY CABLE ASSEMBLY

The battery cable assembly shall be a two-part modular harness.

9.5.1 PART 1 – BATTERY PIG TAIL

Part I shall be equipped with red (+) and black (-) cabling that can be permanently connected to the positive and negative posts of each battery with a 1/4 inch terminal. Each red and black pair shall be terminated into a one-piece Anderson style Power Pole connector or equivalent.

9.5.2 PART 2 – MAIN CABLE

Part II shall be equipped with the mating Power Pole style connector for the batteries and a one-piece, insulated gray Power Pole style connection to the inverter/charger unit. Harness shall be fully insulated and constructed to allow batteries to be quickly and easily connected in any order to ensure proper polarity and circuit configuration.

9.5.3 HARNESS WIRING

All battery cable wiring shall be UL Style 1015 CSA TEW all of proper gauge with respect to design current and with sufficient strand count for flexibility and ease of handling.

9.5.4 BOOTS

Battery terminals shall be covered and insulated with molded boots so as to prevent accidental shorting.

10.0 CABINET

10.1 GENERAL

- The dimensions for the BBS cabinet shall be 48 inches in height, 16.5 inches in width and 16.5 inches in depth.

- The Inverter/Charger Unit shall be shelf or rack mounted on a standard EIA19 inch rack.
- The Automatic Transfer switch shall be mounted on EIA 19” Rail.
- All interconnect wiring shall be provided and shall be UL Style 1015 CSA TEW.

10.2 BBS REPLACEMENT

The BBS equipment and batteries shall be easily replaced and shall not require any special tools for installation.

10.3 HOT SWAPPABLE

The BBS inverter and batteries shall be hot swappable. There shall be no disruption to the Traffic Signal when removing the inverter or batteries for maintenance.

10.4 ANCILLARY INTERNAL INSTALLATION HARDWARE

All necessary internal installation hardware (bolts, fasteners, washers, shelves, racks, etc.) shall be included.

10.5 CABINET SIZING

The external cabinet shall be capable of housing four batteries up to a group 31 size, inverter/charger power module, automatic transfer switch, control panels, wiring, wiring harnesses, and all other ancillary equipment.

10.6 CABINET MOUNTING

The BBS cabinet can be installed either as:

- Free-standing base-mounted cabinet with optional 8” riser for easy cable entrance.
- Pole-mounted cabinet with optional pole mount bracket kit.
- Side-mounted to a Traffic Controller cabinet with no mounting brackets required.

10.7 RATING

All external cabinets shall be NEMA 3R rated. The enclosure shall be made of 0.125 inch (5052-H32) aluminum.

10.8 VENTILATION

The external cabinet shall be ventilated through the use of louvered vents, filter, and a minimum of one thermostatically controlled fan. The filter shall be the re-usable type and matching the dimensions of the louver with both located on the bottom half of the door.

The cabinet fan shall be DC operated for longer reliability.

10.9 ACCESSIBILITY

All components, terminations, terminal blocks, relays, etc. shall be fully accessible.

10.10 SHELVES

Two battery shelves shall be located in the bottom half of the enclosure. The bottom battery shelf shall be removable, and the top battery shelf will be welded to the enclosure sides. Air must be allowed to flow from the bottom of the cabinet and up the back internal wall. Neither the top battery shelf nor the Power Module shelf shall inhibit the airflow to the top of the cabinet.

10.11 LOCKING

The cabinet shall include a 3-point locking system, including a Type 2 Corbin lock and utilize a handle with pad locking capability.

10.12 GENERATOR PLUG COMPARTMENT

The BBS cabinet shall include a generator plug compartment with a flush mounted and gasketed locking access door, which locks the generator power cable in place when connected. The lock shall be a Type 2 Corbin lock. The generator compartment shall include a wired NEMA L5-30P Flanged Inlet connector.

10.13 CABINET OPTIONS

The following options shall be available for the cabinet:

- On-Battery lamp mounted externally on the top of the cabinet that illuminates when the BBS is operating in inverter mode.
- Battery Heater Mats to increase battery capacity in cold climates.
- Receptacle plate assembly that mounts on the transfer switch panel to provide utility power to the battery heater mats.
- Automatic Generator Transfer switch that senses a generator is connected and automatically switches to the generator source.
- Internal lamp with door push-button switch to illuminate the interior of the cabinet.
- Status monitoring dry contacts for the Automatic Transfer Switch and the Generator Transfer Switch.

11.0 REMOTE BATTERY MONITORING SYSTEM

Remote Battery Monitor System (RBMS) shall be permanently installed into the UPS/Battery cabinet to monitor the four UPS batteries (4-12V battery blocks). The RBMS shall have the ability to monitor, read and record both the battery string and individual battery voltages, individual battery admittance (inverse of impedance), and individual battery temperatures and to provide a real-time evaluation of the battery bank health.

The device shall be hardened and operate at a temperature range of -40°F to 175°F. The device shall include four individual 12 volt battery sensors that attach to the top of the battery via adhesive backed hook-loop fasteners. Each sensor shall have an LED for status information.

The RBMS shall have a built-in web interface for communications over Ethernet which is viewable with Chrome and Edge web browsers.

- Battery voltage, admittance, and temperature shall be immediately viewable for each battery upon opening. These values shall be displayed on color coded bar graphs that represent the value. Bar graphs are to be green for no alarm, red for major alarm, and yellow for minor alarm.
- User shall be able to set major and minor, high and low alarms for battery voltage, admittance, and temperature.
- Battery string and delta voltages are to be reported and have user settable major and minor, high and low alarms.
- Baseline admittance shall be user settable. The set baseline admittance will be used by all batteries and will automatically display the percentage difference between the baseline and current state.
- There shall be a checkbox to Flash the Sensor LED on an individual battery, which aids in being able to physically identify it.

The RBMS shall be able send alarm notifications via email and SNMP.

The RBMS shall include software to automatically poll each intersection, up to 1000 devices per software program, reading individual battery voltage, admittance, and temperature, while confirming each is within its user programmable parameters and save this data to a csv file. The software communications shall be SNMP via TCP/IP. The system shall have the ability to program the intervals as to when each reading is taken, by days, weeks or months. The software shall be provided as part of the system cost.

The RBMS shall also perform as a battery balancer, continuously monitoring and balancing all batteries in the string, which can extend the life of the battery. The RBMS shall allow for any single 12V battery within the battery string to be replaced without replacing all batteries in the string during the battery warranty period.

12.0 WARRANTY

12.1 BATTERY BACKUP SYSTEM

The BBS System shall include a 5 year warranty on parts and labor on BBS, Transfer/Bypass Switches, Batteries, and Enclosure System to the Agency when utilizing the BBS Manufacturers own designed enclosure, meeting the above cabinet specifications. The RBMS shall have a 2 year warranty.

12.2 ENCLOSURE

Should the agency decide not to use the enclosure provided by the BBS Manufacturer, the manufacturer shall provide a three-year warranty on parts and labor only on the BBS Inverter Module.

12.3 BATTERIES

The BBS Manufacturer shall provide a 5 year unconditional full replacement warranty for every battery sold to the Agency with the BBS under this specification when the manufacturer's enclosure is used. Under the warranty time period, the battery must provide a minimum of 70% of its original capacity; otherwise it will be considered to be non-compliant to the warranty and replaced at no cost to the Contracting Authority by the BBS manufacturer.

13.0 VENDOR SUPPORT

13.1 TECHNICAL SUPPORT

The BBS manufacturer shall provide at no charge, a toll-free 24/7 technical support phone number. The toll-free phone number shall be included in the BBS manual.

13.2 LOCAL SUPPORT

There shall be a local distributor available to support the product.

13.3 DOCUMENTATION

Equipment manuals shall be provided for each BBS cabinet. Equipment manuals shall include installation, operation, programming, maintenance and troubleshooting.

14.0 QUALITY ASSURANCE

14.1 DESIGN AND PRODUCTION

Each BBS shall be manufactured in accordance with a written manufacturer's Quality Assurance program. The QA program shall include, as a minimum, specific design and production QA procedures.

14.2 ISO CERTIFIED

The BBS Power Module manufacturer shall be ISO 14001 and TL9000 certified.

14.3 UL/CSA

The BBS shall be tested to comply with UL 1778, CSA 22.2 No. 107.3 and must bear the UL CSA mark.

14.4 DESIGN QUALIFICATION TESTING

The manufacturer shall be certified to carry out the CSA and UL standards testing on the BBS system.

F. ELECTRICAL SERVICE PEDESTAL

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

1.0 SERVICE ENCLOSURE

The service enclosure shall meet 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, 43 inches high and 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.

2.0 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 on the internally mounted document drawer.

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

G. VEHICLE DETECTION SYSTEMS

1.0 GENERAL

Where designed, a vehicle detection system shall be provided with each new traffic signal. The vehicle detection system shall be an Aboveground Radar System for both presence and advanced detection, unless otherwise specified in the signal plans. Other acceptable systems shall include a.) Video systems, and b.) loop detectors. The vehicle detection system shall be fully compatible with the City of Council Bluffs' existing signalized infrastructure.

2.0 RADAR PRESENCE DETECTION

2.1 GENERAL

This item shall govern the purchase of aboveground radar presence detector (RPD) equivalent to the Wavetronix SmartSensor^{TM} Matrix.

The presence 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.

2.2.0 SENSOR OUTPUTS

The RPD shall present real-time presence data in ten lanes.

The RPD shall support a minimum of 16 zones.

The RPD shall support a minimum of 16 channels.

The RPD shall support user-selectable zone to channel mapping.

The RPD shall use AND logic to trigger channels when all selected zones are active.

The RPD shall use OR logic to combine multiple zones to a channel output, and shall have channel output extend and delay functionality.

The RPD algorithms shall mitigate detections from wrong way or cross traffic.

The RPD system shall have fail-safe mode capabilities for contact closure outputs if communication is lost.

2.3 DETECTABLE AREA

2.3.1 DETECTION RANGE

The RPD 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 RPD is mounted.

The RPD shall be able to detect and report presence in lanes located within the 140 feet arc from the base of the pole on which the RPD is mounted.

2.3.2 FIELD OF VIEW

The RPD shall be able to detect and report presence for vehicles within a 90 degree field of view.

2.3.3 LANE CONFIGURATION

The RPD shall be able to detect and report presence in up to ten lanes. The RPD shall be able to detect and report presence in curved lanes and areas with islands and medians.

2.4 SYSTEM HARDWARE

For each approach to be detected, one RPD corner radar shall be used.

2.4.1 PREASSEMBLED BACKPLATE

Each RPD shall have a traffic cabinet preassembled backplate with the following:

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

The preassembled backplate for the RPD shall be a cabinet side mount or rack mount.

2.4.2 CONTACT CLOSURE INPUT FILE CARDS

The RPD shall use contact closure input file cards with two or four channel capabilities. The contact closure input file cards for the RPD shall be compatible with industry standard detector racks.

2.5 MAINTENANCE

The RPD shall not require cleaning or adjustment to maintain performance.

The RPD shall not rely on battery backup to store configuration information, thus eliminating any need for battery replacement. Once the RPD is calibrated, it shall not require recalibration to maintain performance unless the roadway configuration changes. The mean time between failures shall be 10 years, which is estimated based on manufacturing techniques.

2.6 PHYSICAL PROPERTIES

The RPD shall not exceed 4.2 pounds in weight.

The RPD shall not exceed 13.2 inches by 10.6 inches by 3.3 inches in its physical dimensions. All external parts of the RPD shall be ultraviolet-resistant, corrosion-resistant, and protected from fungus growth and moisture deterioration.

2.6.1 ENCLOSURE

The RPD shall be enclosed in a Lexan EXL polycarbonate.

The enclosure shall be classified “f1” outdoor weatherability in accordance with UL 746C.

The RPD shall be classified as watertight according to the NEMA 250 standard.

The RPD enclosure 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 RPD shall be able to withstand a drop of up to 5 feet without compromising its functional and structural integrity.

The RPD 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.

2.7 ELECTRICAL

The RPD shall consume less than 10 W.

The RPD shall operate with a DC input between 9 VDC and 28 VDC.

The RPD shall have onboard surge protection.

2.8 COMMUNICATION PORTS

The RPD shall have two communication ports, and both ports shall communicate independently and

simultaneously.

The RPD shall support the upload of new firmware into the RPD's non-volatile memory over either communication port.

The RPD shall support the user configuration of the following:

- Response delay
- Push port

The communication ports shall support a 9600 bps baud rate.

2.9 RADAR DESIGN

The RPD shall be designed with a matrix of 16 radars.

2.9.1 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 up conversion of a digitally generated modulated signal shall preserve the phase stability and frequency stability inherent in the digitally generated signal.

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

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

2.9.2 ANTENNA DESIGN

The RPD antennas shall be designed on printed circuit boards.

The vertical beam width of the RPD 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.

The sidelobes in the RPD two-way antenna pattern shall be -40 dB or less.

Low sidelobes ensure that the performance from the antenna beam widths is fully achieved.

2.9.3 RESOLUTION

The RPD shall transmit a signal with a bandwidth of at least 245 MHz.

2.9.4 RF CHANNELS

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

2.9.5 VERIFICATION

The RPD shall have a self-test that is used to verify correct hardware functionality.

The RPD shall have a diagnostics mode to verify correct system functionality.

2.10 CONFIGURATION

2.10.1 AUTO-CONFIGURATION

The RPD 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 RPD 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.

2.10.2 MANUAL CONFIGURATION

The auto-configuration method shall not prohibit the ability of the user to manually adjust the RPD configuration.

The RPD shall support the configuring of lanes, stop bars and detection zones in 1 foot increments.

2.10.3 WINDOWS® MOBILE-BASED SOFTWARE

The RPD shall include graphical user interface software that displays all configured lanes and the current traffic pattern using a graphical traffic representation.

The RPD shall include the ability to do counting and pulsed channels.

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

2.11 OPERATING CONDITIONS

The RPD 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.

RPD operation shall continue in rain up to 1 inch per hour.

The RPD shall be capable of continuous operation over an ambient temperature range of -40°F to 165.2°F.

The RPD shall be capable of continuous operation over a relative humidity range of 5% to 95% (non-condensing).

2.12 TESTING

2.12.1 FCC

Each RPD 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 RPD shall comply with FCC regulations under all specified operating conditions and over the expected life of the RPD.

2.12.2 NEMA TS 2-2003 TESTING

The RPD 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

2.13 MANUFACTURING

The RPD shall be manufactured and assembled in the USA.

The internal electronics of the RPD 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 RPD 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 RPD by serial number, upon request.

2.14 SUPPORT

The RPD manufacturer shall provide both training and technical support services.

2.14.1 TRAINING

The manufacturer-provided training shall be sufficient to fully train installers and operators in the installation, configuration, and use of the RPD to ensure accurate RPD performance.

The manufacturer-provided training shall consist of comprehensive classroom labs and hands-on, in-the-field, installation and configuration training.

Classroom lab training shall involve presentations outlining and defining the RPD, its functions, and the

procedures for proper operation. These presentations shall be followed by hands-on labs in which trainees shall practice using the equipment to calibrate and configure a virtual RPD. To facilitate the classroom presentation and hands-on labs, the manufacturer-provided training shall include the following items:

- Knowledgeable trainer or trainers thoroughly familiar with the RPD and its processes
- Presentation materials, including visual aids, printed manuals and other handout materials for each student
- Computer files, including video and raw data, to facilitate the virtual configuration of the RPD
- Laptop computers or Windows CE handheld devices with the necessary software, and all necessary cables, connectors, etc.
- All other equipment necessary to facilitate the virtual configuration of the RPD

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.

2.14.2 TECHNICAL ASSISTANCE

Manufacturer-provided technical support shall be available according to contractual agreements, and a technical representative shall be available to assist with the physical installation, alignment, and auto-configuration of each supplied RPD.

Technical support shall be provided thereafter to assist with troubleshooting, maintenance, or replacement of RPDs should such services be required.

2.15 DOCUMENTATION

RPD 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 RPD 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)

2.16 WARRANTY

The RPD shall be warranted free from material and workmanship defects for a period of 2 years from date of shipment.

3.0 RADAR ADVANCE DETECTION

3.1 GENERAL

This item shall govern the purchase of aboveground continuous tracking advance detector (CTAD) equivalent to the Wavetronix SmartSensor™ Advance.

The advanced 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.

3.2 MEASURED QUANTITIES AND OUTPUTS

The CTAD shall detect range, speed, and vehicle estimated time of arrival (ETA) to the stop bar for vehicles or clusters of vehicles moving in the user-selected direction of travel. The CTAD shall also

detect instantaneous roadway efficiency.

The CTAD shall be able to simultaneously detect and report information from up to 25 vehicles on the roadway when they are serially sequenced between the near and far boundaries.

The CTAD shall turn on a zone output when the range, speed, ETA, and qualified count or instantaneous roadway efficiency requirements for that zone are satisfied.

The CTAD shall turn on an alert output on when the user defined zone output combinational logical is satisfied.

The CTAD shall turn on a normal channel output when any of the channel's alerts is on and the channel's delay and extend time constraints are satisfied.

The CTAD shall turn on a latched channel output when the on alert is turned on and the delay time is satisfied. The CTAD shall turn off a latched channel output when the off alert is turned on or the max timer expires and the extension time is satisfied.

The CTAD shall provide vehicle call and extend data on up to eight channels that can be connected to contact closure modules compliant with NEMA TS 1, NEMA TS 2, 170, and 2070 controller cabinets.

The CTAD shall be capable of providing data for each tracked detection over the serial ports.

3.3 DETECTABLE AREA

3.3.1 MOUNTING LOCATION

The CTAD shall be able to detect and report vehicle information when mounted within 50 feet of the center of the lanes of interest.

The CTAD shall be able to detect and report vehicle information when mounted at heights up to 40 feet above the road surface.

3.3.2 DETECTION RANGE

The CTAD shall be able to detect and report information on the roadway located with the near boundary at 50 feet from the base of the pole on which the CTAD is mounted.

The CTAD shall be able to detect and report information on the roadway located with the far boundary at 600 feet from the base of the pole on which the CTAD is mounted.

For incoming traffic, 95% of large vehicles within the line-of-site of the CTAD shall be detected and reported before they arrive 400 feet from the sensor. For incoming traffic, 90% of all motor vehicles within the line-of-site of the CTAD shall be detected and reported before they arrive 400 feet from the sensor.

3.4 PERFORMANCE

3.4.1 DETECTION ACCURACY

The CTAD shall detect at least 98% of large vehicles like truck-trailer combinations and at least 95% of all motor vehicles within the line-of-sight of the CTAD sensor where multiple detections of multiunit vehicles are not considered false detections and merged detections of adjacent lane vehicles are not considered missed detections.

3.4.2 RANGE ACCURACY

The CTAD shall provide range measurements in which 90% of the measurements are accurate within 10 feet when the vehicle is tracked independently.

3.4.3 SPEED ACCURACY

The CTAD shall provide per vehicle speed measurements in which 90% of the measurements are accurate within 5 mph when tracked independently.

3.4.4 ETA ACCURACY

The CTAD shall provide estimated time-of-arrival (ETA) measurements in which 85% of the measurements are accurate within one second, when the detected vehicles are tracked independently at a constant speed above 40 mph and are within 2.5 and 5.5 seconds of the stop bar.

3.5 PERFORMANCE MAINTENANCE

The CTAD shall not require cleaning or adjustment to maintain performance.

The CTAD shall not rely on battery backup to store configuration information, thus eliminating any need for battery replacement.

Once the CTAD is calibrated, it shall not require recalibration to maintain performance unless the roadway configuration changes.

The mean time between failures shall be 10 years, which is estimated based on manufacturing techniques.

3.6 PHYSICAL PROPERTIES

The CTAD shall not exceed 4 pounds in weight.

The CTAD shall not exceed 14 inches by 11 inches by 4 inches in its physical dimensions.

All external parts of the CTAD shall be ultraviolet-resistant, corrosion-resistant, and protected from fungus growth and moisture deterioration.

3.6.1 ENCLOSURE

The CTAD shall be enclosed in a Lexan polycarbonate.

The enclosure shall be classified “f1” outdoor weatherability in accordance with UL 746C.

The CTAD shall be classified as watertight according to the NEMA 250 standard.

The CTAD enclosure 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 CTAD shall be able to withstand a drop of up to 5 feet without compromising its functional and structural integrity.

The CTAD 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.

3.7 ELECTRICAL

The CTAD shall consume less than 4 W @ 12 VDC.

The CTAD shall operate with a DC input between 9 VDC and 28 VDC.

The CTAD shall have onboard surge protection.

3.8 COMMUNICATION PORTS

The CTAD shall have two communication ports, and both ports shall communicate independently and simultaneously.

The CTAD shall support the upload of new firmware into the CTAD's non-volatile memory over either communication port.

The CTAD shall support the user configuration of the following:

- Baud rate
- Communication port response delay
- Contact closure output frequency

Both communication ports shall support all of the following baud rates: 9600, 19200, 38400, 57600 and 115200 bps.

The contact closure output frequency shall be user configurable as short as 10 ms, with a default near 130 ms for compatibility.

Contact closure data shall be reliably communicated over homerun cable connections as long as 600 feet with latency from the time of channel requirement satisfaction to the eventual reporting of the detections on the back edge of the contact closure card in 15 ms or less.

3.9 RADAR DESIGN

3.9.1 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 up conversion of a digitally generated modulated signal shall preserve the phase stability and frequency stability inherent in the digitally generated signal.

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

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

3.9.2 ANTENNA DESIGN

The CTAD antennas shall be designed on printed circuit boards.

The vertical beam width of the CTAD at the 6 dB points of the two-way pattern shall be 65 degrees or

greater.

The horizontal beam width of the CTAD at the 6 dB points of the two-way pattern shall be 11 degrees or less.

The sidelobes in the CTAD two-way antenna pattern shall be -40 dB or less.

3.9.3 RF CHANNELS

The CTAD shall provide at least four RF channels so that multiple units can be mounted in the same vicinity without causing interference between them.

3.10 CONFIGURATION

3.10.1 AUTO-CONFIGURATION

The CTAD shall have a method for automatically configuring the sensitivity of detection in at least 5 foot increments.

The auto-configuration method shall not prohibit the ability of the user to manually adjust the CTAD configuration.

The CTAD shall support the configuration of up to eight channel outputs with up to four alerts per channel and up to four zones per alert, resulting in 32 configurable alerts and 128 configurable zones.

3.10.2 ZONE CONFIGURATION

The CTAD shall support the configuring of zones in 5 foot increments.

The CTAD shall support detection zones as long as 550 feet.

The CTAD shall support user configurable high-speed and low-speed detection filters for each zone.

The CTAD shall support the configuring of speed filters in 1 mph increments.

The CTAD shall support user configurable upper and lower estimated time-of-arrival (ETA) filters for each zone.

The CTAD shall support the configuring of ETA filters in increments of 0.1 seconds.

The CTAD shall provide configurable upper and lower count filters that help determine if a required number of qualified detections are present.

The CTAD shall support the configuring of qualified count filters in increments of one.

3.10.3 WINDOWS®-BASED SOFTWARE

The CTAD shall include graphical user interface software that displays the current traffic pattern using a graphical traffic representation.

The graphical user interface shall also display all configured alerts and provide visual representation of their actuation.

The graphical user interface shall provide a means of logging the vehicular track files with an update rate of greater than five times per second.

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:

- Automatically find the correct baud rate
- Automatically find the correct serial communication port
- Operate over a TCP/IP connection
- Provide a virtual sensor connection for software usability without a sensor
- Give the operator the ability to save/back up the CTAD configuration to a file or load/restore the CTAD configuration from a file

3.11 OPERATING CONDITIONS

The CTAD 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.

CTAD operation shall continue in rain up to 2 inches per hour.

The CTAD shall be capable of continuous operation over an ambient temperature range of -40°F to 165°F.

The CTAD shall be capable of continuous operation over a relative humidity range of 5% to 95% (non-condensing).

3.12 TESTING

3.12.1 FCC

Each CTAD shall be Federal Communications Commission (FCC) certified under CFR 47, part 15, section 15.245 or 15.249 as an intentional radiator.

The FCC certification shall be displayed on an external label on each CTAD according to the rules set forth by the FCC.

The CTAD shall comply with FCC regulations under all specified operating conditions and over the expected life of the CTAD.

3.12.2 NEMA TS 2-1998 TESTING

The CTAD shall comply with the applicable standards stated in the NEMA TS 2-1998 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

3.13 MANUFACTURING

The CTAD shall be manufactured and assembled in the USA.

The internal electronics of the CTAD shall utilize automation for surface mount and wave solder assembly, and shall comply with the requirements set forth in IPC-A-610C Class 2, Acceptability of Electronic Assemblies.

The CTAD 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 CTAD by serial number, upon request.

3.14 SUPPORT

The CTAD manufacturer shall provide both training and technical support services.

3.14.1 TRAINING

The manufacturer-provided training shall be sufficient to fully train installers and operators in the installation, auto-configuration, and use of the CTAD to ensure accurate CTAD performance.

The manufacturer-provided training shall consist of comprehensive classroom labs and hands-on, in-the-field, installation and configuration training.

Classroom lab training shall involve presentations outlining and defining the CTAD, its functions, and the procedures for proper operation. These presentations shall be followed by hands-on labs in which trainees shall practice using the equipment to calibrate and configure a virtual CTAD. To facilitate the classroom presentation and hands-on labs, the manufacturer-provided training shall include the following items:

- Knowledgeable trainer or trainers thoroughly familiar with the CTAD and its processes
- Presentation materials, including visual aids, printed manuals and other handout materials for each student
- Computer files, including video and raw data, to facilitate the virtual configuration of the CTAD
- Laptop computers or Windows CE handheld devices with the necessary software, and all necessary cables, connectors, etc.
- All other equipment necessary to facilitate the virtual configuration of the CTAD

Field training shall provide each trainee with the hands-on opportunity to install and configure the CTAD at the roadside.

Training shall be such that each trainee will mount and align the CTAD correctly.

3.14.2 TECHNICAL ASSISTANCE

The manufacturer-provided technical support shall be available according to contractual agreements and a technical representative available to assist with the physical installation, alignment, and configuration of each supplied CTAD.

Technical support shall be provided thereafter to assist with troubleshooting, maintenance, or replacement of CTADs should such services be required.

3.15 DOCUMENTATION

CTAD documentation shall include a comprehensive user guide as well as an installer quick-reference guide and a user quick-reference guide.

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

- Detection accuracy
- Range accuracy
- Earliest range of detection
- Speed accuracy
- ETA accuracy
- FCC CFR 47 certification
- NEMA 250 standard for Type 4X Enclosure third-party test data
- NEMA TS 2-1998 standard third-party test data

3.16 WARRANTY

The CTAD shall be warranted free from material and workmanship defects for a period of 2 years from date of shipment.

LOOP DETECTORS

4.1 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.

Engineer shall determine if the request should be approved. Preformed loops must be readily available manufactured items. Loops built by the contractor shall not be allowed. 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.

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.

4.2 SAWCUT LOOPS

4.2.1 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.

4.2.2 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.

4.2.3 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 heat shrink tube equal to the Thomas & Betts HS12-6L 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.

4.2.4 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.

4.2.5 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 (6mm) within each loop. A diamond blade with water shall be used in the saw cut operation. Carbide blades are not acceptable.

4.2.6 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.

4.2.7 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.

4.2.8 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.

4.2.9 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.

4.3 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:

a) Induced voltage: There is no deflection of the pointer on a voltmeter.
b) Inductance: The inductance reading on the loop tester is within 10 percent of calculated value.
c) Leakage to ground: The resistance to ground of a newly installed loop exceeds 100 megohms as measured with a 500 volt (V) megohmmeter.
d) Loop resistance: The reading on an ohmmeter is within 10% of the calculated value.
e) The total loop system (loop plus lead-in) inductance is within the acceptable range of the vehicle detector specified in the plan.
f) 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.

H. PEDESTRIAN DETECTION SYSTEM

The pedestrian detection system shall be: POLARA iN2 – iNavigator 2 wire push button stations with the POLARA iCCU-S – iNtelligent Central Control unit or most current model. Equivalent pedestrian detection

systems may also be approved by the City Traffic Engineer.

I. EMERGENCY VEHICLE TRAFFIC SIGNAL PRIORITY CONTROL SYSTEM

The General Traffic Technologies Opticom brand of radio activated, GPS based emergency vehicle traffic signal priority control system (Preempt System) shall be installed in all traffic signal systems.

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.

This item is specified to maintain compatibility with the currently installed system.

J. FIBER OPTIC INTERCONNECT

1.0 GENERAL

All designed interconnect systems shall use single-mode fiber optic, interconnect cable. This work shall consist of furnishing and installing a fiber optic network for a traffic signal system in accordance with Traffic Signal System, Scope of Work as herein before specified and the following. All fiber optic components, except the interconnect cable specified separately, required to provide proper communication with the City Traffic Signal network shall be furnished and installed as a part of this item. These items shall include but not be limited to the following items:

2.0 DISTRIBUTION ENCLOSURE

Field cable shall terminate in the Controller cabinet within a wall mount distribution enclosure. The distribution enclosure shall be dust and moisture repellent. The size of the enclosure shall be adequate for the number of fibers, proper winding area, and splices. The enclosure shall be mounted on the inside cabinet wall or other approved location, which does not interfere with the normal maintenance of the cabinet electronics. The field cable shall be secured to the enclosure in a manner that does not degrade the fiber optic cable but insures a firm and secure mount. The field cable jacket shall be removed and all protective gel shall be removed and the cables and tube areas shall be prepared in accordance with the manufacturer's recommendation. Sufficient lengths of every loose tube shall be coiled within the enclosure to provide spare distance and reach the fiber interface panel. Enclosures shall be 3M brand 8173/W4 <4 coupler> or 8173/W8 <8 coupler> or approved equal. Four fibers from each cable entering the cabinet shall be terminated. All other fibers shall be capped and sealed in accordance with manufacturer's recommendation.

3.0 CONNECTORS

SC type connectors of ceramic ferrule and Physical Contact <PC> end finish shall be used to terminate fibers to equipment. Mechanical connectors shall not be used to splice cables. All fiber connectors used shall be factory installed connectors. No field terminated connectors will be allowed. Connectors shall have a typical insertion loss (single-mode) of 0.15 dB or less, a maximum loss of 0.35 dB or less, with typical reflectance of -55 dB, and temperature stability from -40°C to 75°C. Pigtails shall be rated for the environment they are installed in. Splices shall be neatly stored using manufacturer provided splice organizers within the termination housing.

All terminated strands shall be measured bi-directionally with an OTDR at 1310 nm and 1550 nm. Each connector shall have an averaged bi-directional loss of 0.25 dB or less. Connector tests which exceed the max loss shall be replaced at no cost to the Engineer.

4.0 SPLICES

The fiber cable shall be installed in continuous runs between Controller cabinets unless otherwise specified on the Plans. No splices shall be allowed outside the Controller cabinets. Only mechanical or fusion splices will be allowed when splices are authorized. Pigtail to drop cable splicing shall meet all applicable testing requirements.

Fusion splices shall be used to splice all continuous fiber runs in splice closures and factory terminated connector pigtails. Splices shall be allowed only in the splice closures as shown on the plans. Maximum attenuation per splice as estimated by the fusion splicer shall not exceed 0.08 dB. Any splice exceeding 0.08 dB at the time of splicing shall be re-spliced. Splice shall provide three axis core alignment using light injection and loss measurement techniques. No mechanical splices of fiber cable will be allowed. All fusion splice equipment shall be factory certified within the last year. The Contractor shall provide copies of the certification 10 calendar days prior to splicing.

5.0 FIBER OPTIC CABLE

This work shall consist of furnishing and installing the fiber optic cable of the type, size, and number of fibers specified and all associated accessories. Materials and accessories shall be the standard products of a manufacturer regularly engaged in the manufacture of fiber optic products. All materials and equipment furnished shall be completely free from defects and poor workmanship. All fibers in the cable must be usable and meet specifications. The product provided shall meet the latest applicable standard specifications by American National Standards Institute <ANSI>, Electronics Industries Association <EIA>, and Telecommunications Industries Association <TIA> for the type mode cable of the size specified and the specifications herein. The specific cable used shall be specified in the project plans.

Cable terminations shall be made by a trained and qualified technician with a minimum of 2 years' experience in installing and terminating fiber optic cable. This function may be provided by a person other than the installing Contractor. Upon Request by the Engineer, the Contractor shall provide documentation on qualifications and experience for fiber optic equipment installations. The Engineer shall be the sole judge of the acceptability of the experience level of the proposed individual selected for this function.

6.0 FINAL ACCEPTANCE TESTING

After the complete System is installed and terminated, but excluding the capping of unused fibers, an OTDR reading shall be performed on all cables to insure that each section is in compliance with the issued specification. A hard copy of OTDR signature traces for all fibers for all sections shall be provided to the Engineer. Fibers that have been terminated shall be indicated in the report. In addition to the OTDR test report, the Contractor shall provide the test results of an Attenuation Test for the installed fibers using the insertion loss test procedure and the Transmitter/Receiver Power Level Test and the Continuity Test. The results of all testing shall be recorded along with the date of the test, the name of the person performing the test, brand name, model number and serial number of all equipment used during the test, and any other pertinent information and data (see below). The complete documentation file of all tests conducted and factory tests shall be submitted to the Engineer.
The Contractor shall submit the following documents to the Engineer for approval at least 14 calendar days prior to the acceptance testing.

- Fiber cut-over plan and schedule
- Final test plan and schedule

The Contractor shall perform all testing and the fiber cut-over with the presence of the Engineer or the Engineer's representative(s).

Post installation, 100% of the new cables' fiber or new terminations count shall be tested bidirectionally with an Optical Time Domain Reflectometer (OTDR) at 1310 nm and 1550 nm; in addition, an Optical Loss Test Set (OLTS) shall be used to test all fibers at both wavelengths. Existing fibers that are spliced to or re-spliced as part of this contract shall also be tested in both directions and at both wavelengths. The

Contractor shall provide the Engineer with up to five copies of any software required for viewing electronic files of the OLTS and OTDR traces.

Test results will be recorded on a form supplied by the Contractor, with data compiled in .PDF format through the meter manufacturer's software. No additional alteration using software from the Contractor beyond the meter manufacturer's software will be allowed. The Contractor shall submit test results in a format approved by the Engineer. Completed test forms on each fiber shall be handed over to the Engineer. Contractor shall also provide native test (electronic version) with no alterations and meter software for viewing of fiber traces. At a minimum, test results shall show the following:

- Cable and fiber identification (as approved by Iowa DOT)
- Operator name
- Date and Time
- Setup and test parameters including wavelength, pulse width, range, scale and ambient temperature.
- Test results for OTDR test in both directions for total fiber trace, splice loss/gain (dB), connector loss (dB), all events greater than .05 dB, measured length from cable markings and total length from OTDR.
- Test results for attenuation test including measured cable length (cable marking), total length (from OTDR test), number of splices (from as-built) and total link end-to-end attenuation in each direction and the bidirectional average.

OTDR testing shall use launch and receiving cables minimum 3281 feet or greater than the dead zone for the OTDR used for this test.

All fiber connectors shall be cleaned and checked for dirt, scratches or chips before installed in adapters and testing. All dust covers shall be installed after testing is complete.

The Contractor shall verify prior to submittal to the Engineer for approval that all test results satisfy the requirements of the Contract Documents.

The Contractor shall provide the Engineer a minimum of 4 weeks to review the test results.

All test results submitted to the Engineer by the Contractor are subject to rejection and will not meet final acceptance criteria if the test results are identified as Out of Specifications (OOS) detailed below:

- The fiber optic cable shall have a maximum attenuation of 0.4 dB/km at 1310 nm and 0.3 dB/km at 1550 nm when measured with an OLTS. Fiber test results submitted to the Engineer that exceed the max attenuation loss specification will be identified as OOS.
- Each connector shall have an averaged loss value of 0.25 dB or less when measured bi-directionally with an OTDR at 1310 nm and 1550 nm. Connector test results submitted to the Engineer that exceed the max loss of 0.50 dB in a single direction or an average bi-directional loss of 0.25 dB will be identified as OOS.
- Each splice shall have an averaged loss value of 0.08 dB or less when measured bi-directionally with an OTDR at 1310 nm and 1550 nm. Splice test results submitted to the Engineer that exceed the 0.08 dB will be identified as OOS.

In the event of OOS, the Engineer will reject the test and notify the Contractor to retest. The Contractor shall remove malfunctioning units, replace with new units, and retest meeting the requirements specified above. The Contractor shall submit the test results for the Engineer's approval.

7.0 FIBER OPTIC SLACK, BENDING, AND PULLING

The cable end shall be secured inside the Controller cabinet so that no load is applied to the exposed fiber strands. The minimum bend radius for static storage shall not be less than ten times the diameter of the cable measuring the cable on the outside, or as recommended by the manufacturer.

The minimum bend radius during installation shall not be less fifteen times the diameter of the cable measuring the cable on the outside, or as recommended by the manufacturer. Note: The Contractor should not use tie wrap devices on fiber optic cable due to the force exerted on the fiber and the ease of which this force can permanently damage the fiber.

Slack cable shall be left in each handhole or double handhole, at the top of any conduit riser, junction box, and Controller. This slack cable requirement may be deleted where existing hand holes or through points lack sufficient area to maintain the minimum bend requirements. Where slack has been deleted, extra slack equal to the amount that would have been distributed in the through points shall be equally divided between the two Controller cabinets and shall be in addition to the slack mandated at the cabinets. Each handhole or through point shall be provided with a minimum of 6.5 feet of slack. Controller cabinets shall be provided with a minimum of 19.5 feet. Slack cable shall be coiled and the coils bound at three points around the coil perimeter and supported in their static storage position.

8.0 CABLE INSTALLATION IN CONDUITS

A suitable cable feeder guide shall be used between the cable reel and the face of the conduit. The cable feeder shall be designed to protect the cable and guide the cable directly into the conduit off the reel. During the installation, the cable jacket shall be carefully inspected for jacket defects. If defects are found the Engineer shall be notified prior to any additional cable being installed.

The Contractor shall take unusual care in the pulling of the cable to insure that the cable does not become kinked, crushed, twisted, snapped, etc. A pulling eye shall be attached to the cable and be used to pull the cable through the conduit. A pulling swivel shall be used to preclude twisting of the cable. The cable shall be lubricated prior to entering the conduit with a lubricant recommended by the manufacturer. The lubricant shall be water base type. Dynamometers or break away pulling swing shall be used to insure that the pulling tension does not exceed the specified force of 600 pounds or the cable manufacture's recommendations, whichever is less. The mechanical stress on the cable shall not allow the cable to twist, stretch, become crushed, or forced around sharp turns, which exceed the bend radius or scar or damage the jacket. The pulling of the cable shall be hand assisted at each pull point.

At each hand hole or through point and at the cabinet, the cable shall be visibly marked or tagged as "CAUTION-FIBER OPTIC CABLE."

An insulated copper wire, No. 12 AWG shall be pulled in the same conduit as the fiber optic cable in order to trace the installation. The ends of the trace wire shall be insulated and terminated in the last hand hole prior to the Controller cabinet. Due to the electrical conducting characteristics of the wire, especially during electrical storms, the wire shall not enter any Controller cabinet.

9.0 DISRUPTION TO EXISTING FIBER NETWORKS

Planned Disruption

- The Contractor shall ensure continuous operation of the existing fiber networks and systems during construction of the project. The Contractor shall be responsible for repairing, to Iowa DOT's satisfaction and at no cost to Iowa DOT, any damage the Contractor causes to the existing fiber networks and systems during the life of the project.
    - Existing Fiber Assignments and Ownership: The Iowa DOT, Iowa Communications Network (ICN) and the City of Council Bluffs share tubes and strands in the existing 96 SM Fiber backbone cable shown on the plans. ICN maintains the existing fiber cable. The Iowa DOT is assigned the Blue (BL), Orange (OR), Green (GR) and Brown (BR) tubes. ICN is assigned the Slate (SL) and White (WH) tubes. The City of Council Bluffs is assigned the Red (RD) and Black (BK) tubes.
- The Contractor shall not work on splicing, disconnecting and/or in any way disrupting normal operation of the existing fiber networks or systems. Parties include the Iowa DOT, the City of Council Bluffs and the Iowa Communications Network (ICN). The Contractor shall provide a written request to the Iowa DOT and the respective parties for approval at least 10 calendar

days before the existing fiber network or equipment is disrupted. A copy of the written request shall be submitted to the Engineer in all cases. In addition to the written request, the Contractor shall submit the work plan and schedule for approval by the Engineer. The work plan shall include all fiber strands and the parties being affected.

- The Contractor shall restore the disrupted system upon completion of the Work within the allowable working hours. The Contractor shall remain on site until Iowa DOT notifies that the disrupted systems are fully operational. Failure of the Contractor to restore disrupted systems and equipment within the allowable working hours will constitute an unplanned disruption.

Allowable Working Hours

- The Contractor shall only disrupt existing fiber according to the allowable working hours as follows.
    - Iowa DOT, ICN and City of Council Bluffs IT (BL, OR, GR, BR, SL, WH, RD)
        - Disruptions will not be allowed.
    - City of Council Bluffs Traffic Signal (BK)
        - Disruptions to the traffic signals shall be limited to no more than 7 Calendar days.

Unplanned Disruption

- Any unplanned disruptions determined by the Engineer to be caused by the actions of the Contractor shall be corrected by the Contractor at no additional cost to Iowa DOT.
- In the case of an unplanned disruption and subsequent notification by the Engineer, the Contractor shall immediately stop all other work in progress and shall expend all of its efforts to restore the disrupted system(s) or correct the problem causing the disruption. The Contractor will not be granted an extension of time for delays caused by repairing disrupted systems. Unplanned disruptions shall result in the assessment of liquidated damages.

Liquidated Damages

- Unplanned disruptions to the existing fiber optic network will result in impacts to the traveling public, increase fuel consumption, vehicle operating costs, pollution, and time needed for Iowa DOT administration, engineering, inspection, and supervision, and other inconveniences and harm far in excess of those resulting from delay of most projects.

  Accordingly, the Contractor agrees:

    - To pay $500.00 liquidated damages per 60 minutes, for each 60 minute period that the Contractor fails to restore the proper operation of an existing fiber-optic network element following an unplanned disruption lasting longer than 6 hours.
    - To authorize the Engineer to deduct these liquidated damages from any money due or coming due to the Contractor.

K. TRAFFIC MONITORING CAMERA

1. GENERAL.

All new traffic signals shall have Pan-Tilt-Zoom cameras installed. Camera shall be Axis Communications Q6125-LE. This camera is required to maintain interoperability with the City's current monitoring software. It will also maintain compatibility and continuity with the City's Intelligent Transportation System.

2. POWER SUPPLY.

Camera shall be powered by High Power over Ethernet (IEEE 802.3at). Any devices necessary for providing power to the camera shall be included.

3. MOUNTING HARDWARE.

A mounting bracket capable of attaching the camera to the side of a steel traffic signal pole shall be included. Mounting hardware shall be supplied by the camera manufacturer.

4. DECODING SOFTWARE.
Decoding software shall be industry-accepted and widely available.

5. WARRANTY

Supplier warrants that all products supplied will be free from defects in design, workmanship and materials under normal use for a minimum period of 1 year from the date of the original purchase.

L. GROUNDING SYSTEM

An equipment grounding conductor (EGC) shall be installed to electrically bond together all non-current 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 No. 2/0 copper cable. Bolt type clamps shall not be used. A common No. 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 No. 6 copper wire to a 5/8 inch by 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 bonded to the EGC. 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.

M. 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 120/240 Single Phase Split Phase VAC power source to the Meter Pedestal and the branch circuits to the proposed signal cabinet and proposed luminaires. 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. 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 signal.

N. 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 1 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 Contracting Authority 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.

O. TRAFFIC SIGNAL HEADS

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 assemblies shall be aluminum.

Side of pole signal mounting hardware shall be polycarbonate yellow saddle brackets. Brackets shall be secured to the pole by using minimum 5/8 inch wide stainless steel banding material

All signal heads placed on mast arms shall be provided with backplates. Backplates shall be of 5 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.

All vehicle signal indications (red, yellow and green) shall be LED 12 inch display or an approved equal. 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 LED Ball Signal Modules shall be fully compliant to the ITE VTCSH LED Circular Supplement specifications dated and adopted June 27, 2005.

All LED Arrow Signal Modules shall be fully compliant to the “Omni-directional” specifications of the ITE VTCSH -LED Vehicle Arrow Traffic Signal Supplement adopted July 1, 2007.

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).

P. MAST ARMS AND POLES

1.0 GENERAL

All steel traffic signal mast arm pole assemblies shall be designed and detailed by the manufacturer supplying the poles. 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.

Use mast arm length and vertical pole height as specified in the contract documents.

Ensure the mast arms, poles, and supporting bases are galvanized on both interior and exterior surfaces according to ASTM A 123.

Use continuously tapered, round, steel poles of the transformer base type. Fabricate poles from low carbon (maximum carbon 0.30%) steel of U.S. standard gauge.

Ensure minimum yield strength of 48,000 psi after manufacture. Supply base and flange plates of structural steel complying with ASTM A 36 and cast steel complying with ASTM A 27, Grade 65-35 or better.

Where a combination street lighting/signal pole is specified in the contract documents, ensure the luminaire arm is mounted in the same vertical plane as the signal arm unless otherwise specified. Use a luminaire arm of the single member tapered type. Fabricate the pole with a minimum 4 inch by 6 inch handhole and cover located opposite the signal mast arm.

If allowed by the Engineer, poles and mast arms may be fabricated by shop welding two sections together, resulting in a smooth joint as follows:

- Ensure a minimum of 60% penetration for longitudinal butt welds in plates 3/8 inch and less in thickness, except within 1 foot of a transverse butt-welded joint. Ensure a minimum of 80% penetration for longitudinal butt welds in plates over 3/8 inch in thickness.
- Ensure 100% penetration for longitudinal butt welds in poles and arms within 1 foot of a transverse butt-welded joint.
- Ensure 100% penetration for transverse butt welds by using a back-up ring or bar to connect the sections.

- Examine the full length of all transverse butt welds and 100% penetration longitudinal butt welds by ultrasonic inspection according to the requirements of ANSI/AWS D1.1.
- Comply with ANSI/AWS D1.1 except as modified by Iowa DOT Article 2408.03, B.

Provide non-shrink grout (complying with Materials I.M. 491.13) or a rodent guard (complying with Materials I.M. 443.01) for placement between the pole base and the foundation.

2.0 POLE DESIGN

Comply with AASHTO 2013 Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. Use a 90 mph basic wind speed with a 50 year mean recurrence interval for strength design. Use Category II for fatigue design. Apply only natural wind gust loads (i.e. do not apply galloping loads, vortex shedding loads, or truck-induced gust loads) for fatigue design. Install vibration mitigation devices on all traffic signal pole mast arms over 60 feet in length.

3.0 HARDWARE

3.1 GENERAL

Equip poles and mast arms with all necessary hardware and anchor bolts to provide for a complete installation without additional parts.

Furnish each anchor bolt with one leveling nut, one anchoring nut, and one jam nut (if required) on the exposed end and one of the following on the embedded end: nut, nut and plate, or nut and anchor bolt assembly ring plate. Use anchor bolts, nuts, and washers that comply with Materials I.M. 453.08.

3.2 ANCHOR BOLTS

Use straight full-length galvanized bolts.

Comply with ASTM F 1554, Grade 105, S4 (-20°F).

Threads are to comply with ANSI/ASME B1.1 for UNC thread series, Class 2A tolerance.

The end of each anchor bolt intended to project from the concrete is to be color coded to identify the grade.

Do not bend or weld anchor bolts.

3.3 NUTS

Comply with ASTM A 563, Grade DH or ASTM A 194, Grade 2H.

Use heavy hex.

Use ANSI/ASME B1.1 for UNC thread series, Class 2B tolerance.

Nuts may be over-tapped according to the allowance requirements of ASTM A 563.

Refer to Article 2522.03, H, 2, a through h, for tightening procedure and requirements.

3.4 WASHERS
Comply with ASTM F 436 Type 1.

3.5 GALVANIZING

Galvanize entire anchor bolt assembly consisting of anchor bolts, nuts, and washers (and plates or anchor bolt assembly ring plate, if used) according to the requirements of ASTM B 695, Class 55 Type 1 or ASTM F 2329 with zinc bath temperature limited to 850°F. Galvanize entire assembly by the same zinc-coating process, with no mixed processes in a lot of fastener assemblies.

Q. POLE BASES

All concrete pole bases shall be designed as per the standard plans. 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 by the Engineer prior to fabrication.

R. 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.

S. ELECTRICAL CABLE

1.0 GENERAL

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 degrees C., equal or better. Conductors used in the Controller cabinet shall conform to the NEC color codes:

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

2.0 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.

3.0 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.

4.0 LOOP DETECTOR WIRE (WITH PLASTIC TUBING)

The loop wire shall meet the requirements of the IMSA specification 51-5, latest revision thereof for a nylon or cross-linked 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.

5.0 DETECTOR LEAD-IN CABLE

Detector lead-in cable shall meet the requirements of 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.

6.0 ETHERNET CABLE

Ethernet cable for exterior signal devices shall have No. 24 AWG Bonded-Pairs, solid bare copper conductors, polyolefin insulation, polymer gel waterblocked, with a sun resistant LLPE jacket. Cable will have sequential marking at 2 foot intervals.

Cable shall be Belden 7934a or equivalent.

7.0 TRACER CABLE AND LOCATE BOX

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.

The Contractor shall provide a Locate Box outdoor-rated station protector on the outside of traffic controller cabinets. The Contractor shall run a ground wire to the main ground breaker of the traffic controller and run the fiber locate wires to the pedestals in the station protector. All tracer wires shall be interconnected to the ground post. The box shall be mounted to the exterior of the signal cabinet. A ground wire shall be attached to a lug within the box from the signal cabinet.

8.0 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 No. 6 copper cable.

All grounding conductors that connect bonding bushings to grounding systems shall be a No. 6 copper cable.

All grounding conductors between terminal strip support plates and the cabinet grounding bus shall be a minimum of a No. 10 copper cable or a braided copper cable with equal cross sectional area.

T. 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 can be 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 2 inches beyond the wire splice at 1 inch increments to act as a strain relief to the splice.

U. SIGNING

The Contractor shall furnish and install all regulatory and information signs as per project plans. The signs shall meet current MUTCD specifications in relation to size and message standards. The signs shall use urban rated prismatic reflective sheeting. The City of Council Bluffs Traffic Maintenance Division shall supply the mast arm street name signs, which shall be installed by the Contractor. Any required brackets and/or supports for the mast arm signs shall be furnished by the Contractor.

V. LED ROADWAY LUMINAIRES

1.0 NORMATIVE REFERENCES

The publications listed below form a part of this specification to the extent referenced. Publications are referenced within the text by their basic designation only. Versions listed shall be superseded by updated versions as they become available.

American National Standards Institute (ANSI)

- C78.377-2011 (or latest), American National Standard for the Chromaticity of Solid State Lighting Products
- C82.77-2002 (or latest), American National Standard for Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment
- C136.2-2014 (or latest), American National Standard for Roadway and Area Lighting Equipment – Dialectric Withstand and Electrical Immunity Requirements

- C136.10-2010 (or latest), American National Standard for Roadway and Area Lighting Equipment – Locking-Type Photocontrol Devices and Mating Receptacles—Physical and Electrical Interchangeability and Testing
- C136.15-2011 (or latest), American National Standard for Roadway and Area Lighting Equipment – Luminaire Field Identification
- C136.22-2004 R2009 (or latest), American National Standard for Roadway and Area Lighting Equipment – Internal Labeling of Luminaires
- C136.31-2010 (or latest), American National Standard for Roadway Lighting Equipment – Luminaire Vibration
- C136.37-2011 (or latest), American National Standard for Roadway and Area Lighting Equipment - Solid State Light Sources Used in Roadway and Area Lighting
- C136.41-2013 (or latest), American National Standard for Roadway and Area Lighting Equipment—Dimming Control Between an External Locking Type Photocontrol and Ballast or Driver

American Society for Testing and Materials International (ASTM)

- B117-11 (or latest), Standard Practice for Operating Salt Spray (Fog) Apparatus
- D523-08 (or latest), Standard Test Method for Specular Gloss
- D1654-08 (or latest), Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
- G154-06 (or latest), Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

ENERGY STAR®

- ENERGY STAR TM-21 Calculator, rev. 020712 (or latest, www.energystar.gov/TM-21Calculator)

Federal Communications Commission (FCC)

- 47 CFR Part 15, Telecommunication – Radio Frequency Devices

Federal Trade Commission (FTC)

- Complying with the Made in USA Standard, December 1998 (http://business.ftc.gov/advertising-and-marketing/made-usa)
- Green Guides, 16 CFR Part 260, Guides for the Use of Environmental Marketing Claims

Illuminating Engineering Society of North America (IESNA or IES)

- LM-50-13 (or latest), IES Approved Method for Photometric Measurement of Roadway and Street Lighting Installations
- LM-61-06 (or latest), IESNA Approved Guide for Identifying Operating Factors Influencing Measured Vs. Predicted Performance for Installed Outdoor High Intensity Discharge (HID) Luminaires
- LM-63-02 (R2008 or latest), ANSI/IESNA Standard File Format for the Electronic Transfer of Photometric Data and Related Information
- LM-79-08 (or latest), IESNA Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products
- LM-80-08 (or latest), IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources
- RP-8-00 (or latest), ANSI / IESNA American National Standard Practice for Roadway Lighting
- RP-16-10 (or latest), ANSI/IES Nomenclature and Definitions for Illuminating Engineering
- TM-3-95 (or latest), A Discussion of Appendix E - "Classification of Luminaire Lighting Distribution," from ANSI/IESNA RP-8-83
- TM-15-11 (or latest), Luminaire Classification System for Outdoor Luminaires

- TM-21-11 (or latest), Projecting Long Term Lumen Maintenance of LED Light Sources

International Electrotechnical Commission (IEC)
- 60929 Annex E, Control Interface for Controllable Ballasts (0-10V)
- 62386, Digital Addressable Lighting Interface (DALI)

LED Lighting Facts
- Submission Requirements (http://www.lightingfacts.com/About/Content/Manufacturers/SubmissionRequirements)

Municipal Solid-State Street Lighting Consortium (MSSLC)
- Model Specification for Networked Outdoor Lighting Control Systems, V2.0 (or latest)

National Electrical Manufacturers Association (NEMA)
- LSD 63-2012, Measurement Methods and Performance Variation for Verification Testing of General Purpose Lamps and Systems

Underwriters Laboratories (UL)
- 1598 Third Edition (or latest), Luminaires

2.0 DEFINITIONS

Lighting terminology used herein is defined in IES RP-16. See referenced documents for additional definitions.

- Exception: The term “driver” is used herein to broadly cover both drivers and power supplies, where applicable.
- Clarification: The term “LED light source(s)” is used herein per IES LM-80 and TM-21 to broadly cover LED package(s), module(s), and array(s).

3.0 PRODUCT REQUIREMENTS

This specification applies to luminaires for new installations or replacements at signalized highway intersections within the City of Council Bluffs.

Tabulated summary of key parameters and product criteria

Table 1: Luminaire Designation: “250W HPS Equivalent LED”

PERFORMANCE CRITERIA LED LUMINAIRE		
INPUT POWER	Max. nominal luminaire input power	108 W
VOLTAGE	Nominal luminaire input voltage (or range as applicable)	120 V
LUMEN MAINT.	Min. % of initial output at 36,000 hours operation	90%
WARRANTY	Min. luminaire warranty	10 years
NOMINAL CCT	Rated correlated color temperature	4000 ± 350 K
BUG RATING	Max. nominal backlight-uplight-glare ratings	B2-U0-G2
DOWNWARD OUTPUT	Min. *maintained* luminaire output below horizontal	10,800 lm
FINISH	Luminaire housing finish color	Gray
WEIGHT	Max. luminaire weight	30 lb
LIGHT DISTRIBUTION	Distribution Type and Range	TYPE III Medium

MOUNTING	Mtg. method	☐ Post-top ☑ Side-arm ☐ Trun./yoke ☐ Swivel-tenon		
	Tenon nominal pipe size (NPS)			2 inches
VIBRATION	ANSI C136.31	☑ Level 1 (normal) ☐ Level 2 (bridge/overpass)		
THERMAL ENVIRONMENT	Typical min. ambient temperature during operation			-20 °C
	Typical max. ambient temperature during operation			40 °C
ELECTRICAL IMMUNITY	ANSI C136.2 Comb. Wave Test Level	☑ Basic (6kV / 3kA)	☐ Enhanced (10kV / 5kA)	☐ Elevated (20kV / 10kA)
CONTROL INTERFACE	☐ None	☐ ANSI C136.10 (3-pin)	☑ ANSI C136.41, 5-pin	☐ ANSI C136.41, 7-pin
LED DRIVER	☐ Not dimmable	☑ Dimmable, 0-10V (IEC 60929)	☐ Dimmable, DALI (IEC 62386)	

3.1 GENERAL REQUIREMENTS

Luminaires shall satisfy the key criteria summarized in Section 3.0.

Transmissive optical components shall be applied in accordance with OEM design guidelines to ensure suitability for the environment (e.g., electromagnetic, thermal, mechanical, chemical).

Luminaire shall be designed for ease of component replacement and end-of-life disassembly.

LED light source(s) and driver(s) shall be RoHS compliant.

Nominal luminaire input wattage shall account for nominal applied voltage and any reduction in driver efficiency due to sub-optimal driver loading.

Luminaire shall accept the voltage or voltage range specified at 50/60 Hz, and shall operate normally for input voltage fluctuations of +/- 10%.

All internal components shall be assembled and pre-wired using modular electrical connections.

The following shall be in accordance with corresponding sections of ANSI C136.37:

- Wiring and grounding
- Terminal blocks for incoming AC lines (electrical mains wires)
- Photocontrol receptacle
- Latching and hinging
- Mounting provisions
- Ingress protection

3.2 PAINTED OR FINISHED LUMINAIRE SURFACES EXPOSED TO THE ENVIRONMENT

Shall exceed a rating of six per ASTM D1654 after 1000 hours of testing per ASTM B117.

The coating shall exhibit no greater than 30% reduction of gloss per ASTM D523, after 500 hours of QUV testing at ASTM G154 Cycle 6.

3.3 THERMAL MANAGEMENT

Luminaire shall start and operate in ambient temperature range specified.

Maximum rated case temperature of driver and other internal components shall not be exceeded when luminaire is operated in ambient temperature range specified.

Mechanical design of protruding external surfaces (heat sink fins) shall facilitate hose-down cleaning and discourage debris accumulation.

Liquids or other moving parts shall be clearly indicated in submittals, shall be consistent with product testing, and shall be subject to review by Owner.

3.4 LED DRIVER, PHOTOCONTROL RECEPTACLE, AND CONTROL INTERFACE

Luminaire designation(s) indicated “None” in Table 1 need not accept a control signal, and do not require a dimmable driver. If luminaire cannot be furnished without photocontrol receptacle, luminaire shall be furnished with ANSI C136.10 compliant photocontrol receptacle and shorting cap as directed by Owner.

Luminaire designation(s) indicated “ANSI C136.10, 3-pin” in Table 1 shall be fully prewired and shall incorporate an ANSI C136.10 compliant receptacle. If a dimmable LED driver is specified, its control wires shall be accessible and electrically isolated.

Luminaire designation(s) indicated “ANSI C136.41, 5-pin” in Table 1 shall be fully prewired and shall incorporate an ANSI C136.41 compliant receptacle. If a dimmable LED driver is specified, its 0-10V or DALI control wires shall be connected to the receptacle pads as specified in ANSI C136.41.

Luminaire designation(s) indicated “ANSI C136.41, 7-pin” in Table 1 shall be fully prewired and shall incorporate an ANSI C136.41 compliant receptacle. If a dimmable LED driver is specified, its 0-10V or DALI control wires shall be connected to the receptacle pads as specified in ANSI C136.41; connection of the two remaining pads shall be by Supplier, as directed by the Engineer.

3.5 ELECTRICAL SAFETY TESTING

Luminaire shall be listed for wet locations by a U.S. Occupational Safety Health Administration (OSHA) Nationally Recognized Testing Laboratory (NRTL).

Luminaire shall have locality-appropriate governing mark and certification.

Luminaire shall meet the performance requirements specified in ANSI C136.2 for dielectric withstand, using the DC test level and configuration.

3.6 ELECTRICAL IMMUNITY

Luminaire shall meet the performance requirements specified in ANSI C136.2 for electrical immunity, using the combination wave test level indicated in Table 1.

Manufacturer shall indicate on submittal form (Section 9) whether failure of the electrical immunity system can possibly result in disconnect of power to luminaire.

3.7 INTERFERENCE AND POWER QUALITY

Luminaire shall comply with FCC 47 CFR part 15 interference criteria for Class A (non-residential) digital devices.

Luminaire shall comply with section 5.2.5 (luminaires rated for outdoor use) of ANSI C82.77 at full input power and across specified voltage range.

3.8 COLOR ATTRIBUTES

Color Rendering Index (CRI) shall be no less than 60.

Nominal Correlated Color Temperature (CCT) shall be as specified in Table 1.

If submitted nominal CCT is listed in Table 2 below, measured CCT and Duv shall be as listed in Table 2.

Table 2: Allowable CCT and Duv (adapted from ANSI C78.377)

Manufacturer-Rated Nominal CCT (K)	Allowable IES LM-79 Chromaticity Values	
	Measured CCT (K)	Measured Duv
2700	2580 to 2870	-0.006 to 0.006
3000	2870 to 3220	-0.006 to 0.006
3500	3220 to 3710	-0.005 to 0.007
4000	3710 to 4260	-0.005 to 0.007
4500	4260 to 4746	-0.004 to 0.008
5000	4746 to 5311	-0.004 to 0.008
5700	5312 to 6020	-0.003 to 0.009
6500	6022 to 7040	-0.003 to 0.009

If submitted nominal CCT is not listed in Table 2, measured CCT and Duv shall be as per the criteria for Flexible CCT defined in ANSI C78.377.

3.9 IDENTIFICATION

Luminaire shall have an external label per ANSI C136.15.

Luminaire shall have an internal label per ANSI C136.22.

3.10 PHOTOCONTROLS

Luminaire shall be furnished with a photocontrol as specified.

The locking-type photocontrol shall be an electronic control based on a solid-state photo sensor and relay switch circuit.

Switch operation shall have a rating of 1000 Watts tungsten and 1800 Watts ballast at 105-305 VAC.

For high in-rush LED type fixtures, the photocontrol switch operation shall have an 8 Amp Electronic Ballast rating at 105-305 VAC.

The photocontrol should fail in an ON state.

The photocontrol operating voltage shall be clearly identified on the control housing.

The photocontrol shall be equipped with a 2 to 5 second delay action eliminating activation by light flashes.

The photocontrol shall be equipped with standard 3-prong twist and locking-type plug connection. The plug connection terminals shall be solid brass.

The photocontrol shall consist of industrial grade electronic components, 510 Joule MOV, solid state light sensor, and silver alloy relay contacts.

The photocontrol shall be 100% factory tested and function within specified light levels. The photo control shall be agency certified and tested accordingly.

The photocontrol shall meet agency standards for locking-type devices and all other requirements of ANSI C136.10-2010.

The photocontrol shall operate over a temperature range of -40°F to 158°F.

The photocontrol should have a manufacturer's limited warranty of 12 years minimum.

4.0 REQUIRED SUBMITTALS

Electronic submittals are preferred.

4.1 COMPLETED SECTION 9 SUBMITTAL FORM

Family grouping in accordance with LED Lighting Facts is permitted, provided this is clearly indicated on the submittal form provided in Section 9, and clearly communicated via a letter that includes detailed calculations relating the tested product(s) to the submitted product.

4.2 PRODUCT CUTSHEETS

Luminaire cutsheets

Cutsheets for LED light source(s)

Cutsheets for LED driver(s)

- If dimmable LED driver is specified, provide diagrams illustrating light output and input power as a function of control signal.

Cutsheets for surge protection device, if applicable

4.3 INSTRUCTIONS FOR INSTALLATION AND MAINTENANCE

4.4 SUMMARY OF LUMINAIRE RECYCLED CONTENT AND RECYCLABILITY

Shall be in accordance with the FTC Green Guides, expressed as a percentage of luminaire weight.

4.5 IES LM-79 LUMINAIRE PHOTOMETRIC REPORT(S)

Shall be produced by the test laboratory

The test laboratory shall satisfy LED Lighting Facts accreditation requirements.

Shall include the following information

- Name of test laboratory
- Report number
- Date
- Complete luminaire catalog number
- Description of luminaire, LED light source(s), and LED driver(s)
- Goniophotometry
    - IES TM-15 Backlight-Uplight-Glare (BUG) ratings shall be for initial (worst-case) values, i.e., Light Loss Factor (LLF) = 1.0.

- If luminaires are tilted upward for calculations in section 0, BUG ratings shall correspond to the same angle(s) of tilt.

4.6 LUMEN MAINTENANCE CALCULATIONS AND SUPPORTING TEST DATA

Shall be in accordance with LED Lighting Facts guidance.

- Exception: calculations shall be based on the cumulative hours of operation specified in Table 1.

Submit completed ENERGY STAR TM-21 Calculator as an electronic Excel file.

4.7 COMPUTER-GENERATED POINT-BY-POINT PHOTOMETRIC ANALYSIS OF MAINTAINED LIGHT LEVELS

Calculation/measurement points shall be per IES RP-8. Separated vehicular lanes, bikeways, and walkways shall be evaluated separately.

Calculations shall be for maintained values, i.e. Light Loss Factor (LLF) < 1.0, where LLF = LLD x LDD x LATF, and

- Lamp Lumen Depreciation (LLD) shall be 0.90 or the value calculated in section 0, whichever is lower.
- Luminaire Dirt Depreciation (LDD) = 0.90
- Luminaire Ambient Temperature Factor (LATF) = 0.96

Mesopic multipliers (i.e., effective luminance factors) shall not be used. All values shall assume photopic visual adaptation.

Submit IES LM-63 format electronic file containing luminous intensity data associated with submitted LM-79 report(s) and used for point-by-point calculations.

4.8 SUMMARY OF JOINT ELECTRON DEVICES ENGINEERING COUNCIL (JEDEC) OR JAPAN ELECTRONICS AND INFORMATION TECHNOLOGY INDUSTRIES (JEITA) RELIABILITY TESTING PERFORMED FOR LED PACKAGES

4.9 SUMMARY OF RELIABILITY TESTING PERFORMED FOR LED DRIVER(S)

4.10 WRITTEN PRODUCT WARRANTY AS PER SECTION 0 BELOW

Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratory).

4.11 DOCUMENTATION SUPPORTING ANY U.S. ORIGIN CLAIMS FOR THE PRODUCT, IN ACCORDANCE WITH FTC GUIDANCE.

5.0 QUALITY ASSURANCE

Before approval and purchase, Owner may request luminaire sample(s) identical to product configuration(s) submitted for inspection. Owner may request IES LM-79 testing of luminaire sample(s) to verify performance is within manufacturer-reported tolerances.

Electrically test fully assembled luminaires before shipment from factory.

After installation, Owner may perform IES LM-50 field measurements to verify performance requirements, giving consideration to manufacturing tolerances and measurement uncertainties as outlined in IES LM-61 and NEMA LSD 63.

6.0 WARRANTY

Warranty shall be of the minimum duration specified in Table 1, and shall cover maintained integrity and functionality of the following:

- Luminaire housing, wiring, and connections
- LED light source(s)
  - Negligible light output from more than 10 percent of the LED packages constitutes luminaire failure.
- LED driver(s)

Warranty period shall begin 90 days after date of invoice, or as negotiated by owner such as in the case of an auditable asset management system.

7.0 MANUFACTURER SERVICES

Manufacturer or local sales representative shall provide installation and troubleshooting support via telephone and/or email.

8.0 ELIGIBLE MANUFACTURERS

Any manufacturer offering products that comply with the required product performance and operation criteria may be considered.

9.0 PRODUCT SUBMITTAL FORM

Luminaire designation	**250W HPS Equivalent LED**			
Luminaire manufacturer				
Luminaire model number				
Nominal IES TM-15 BUG ratings	B =	U =	G =	
Product family testing	☐ Submitted product is identical to tested product	☐ Submitted product differs from tested product(s) as explained in attached letter		
Housing finish color				
Tenon nominal pipe size	inches			
Nominal luminaire weight	lb			
Nominal luminaire EPA	ft^2			
Nominal luminaire input voltage	V			
Control interface	☐ None	☐ ANSI C136.10 (3-pin)	☐ ANSI C136.41, 5-pin	☐ ANSI C136.41, 7-pin
LED driver	☐ Not dimmable	☐ Dimmable, 0-10V (IEC 60929)	☐ Dimmable, DALI (IEC 62386)	
Electrical immunity—ANSI C136.2 combination wave test level	☐ Basic (6kV / 3kA)	☐ Enhanced (10kV / 5kA)	☐ Elevated (20kV / 10kA)	
Upon failure of electrical immunity system	☐ Possible disconnect	☐ No possible disconnect		
ANSI C136.31 vibration test level	☐ Level 1 (Normal)	☐ Level 2 (bridge/overpass)		
Thermal management	☐ Liquids or moving parts	☐ No liquids or moving parts		
Luminaire warranty period	Years			
Rated life of LED driver(s)	Hours			
IES LM-80 test duration	Hours			
LED lumen maintenance *	☐ Reported (restricted)	☐ Calculated (unrestricted)		
Make/model of LED light source(s)				
	Nominal value	Tolerance (%)		
Luminaire input power—initial	W	W		
Luminaire input power—maintained **	W	W		
LED drive current—initial	mA	mA		
LED drive current—maintained **	mA	mA		
In-situ LED T_s	°C	°C		
LED lumen maintenance **	%	%		
CCT	K	K		
Additional product description				

* Manufacturer shall indicate which is applicable (check only one box) as per section 0 . According to IES TM-21, “Reported” values are restricted to 5.5x or 6x (depending on sample size) the duration of IES LM-80 testing, whereas “Calculated” (i.e., projected) values are unrestricted.

** As per section 4.6.

W. 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.

X. SIGNAL DOWNTIME

The existing traffic signals shall remain in operation during this project until the new permanent signal is in operation and the new ramp intersection is open to traffic. Any signal downtime shall not occur during peak hours. The peak hours are Monday - Friday, 6:00 A.M to 9:00 A.M and 2:00 P.M to 6:00 P.M.

The Contractor at all times shall conduct the operation in such a manner as to insure the safety of the motorist, the pedestrian, and its own employees. The Contractor shall perform work in such a manner and sequence as to maintain vehicular and pedestrian traffic at all times and to maintain access to adjacent private properties, unless otherwise specified in the plans.

The Contractor shall furnish, install, and maintain all devices for directing, warning and rerouting traffic flow, including warning lights, barricades, and other devices necessary to adequately inform the motorist of unusual or unsafe conditions and guide them safely through the Project work area.

All required barricades and signs shall be in accordance with Part VI of the MUTCD.

Y. 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.

Z. CONTRACTOR QUALIFICATIONS & RESPONSIBILITIES

The contractor must be licensed as an Electrical Contractor as required by Iowa law and shall have a licensed master electrician on staff.

The contractor is responsible for arranging and successful inspection by the City Electrical Inspector. The contractor shall be responsible for resolving all deficiencies identified by the City Electrical Inspector.

During construction of the project, it may be necessary for the DOT, the Contractor, or the City to respond to a traffic signal operation malfunction. In the event of a traffic signal operations issue, the following will outline the roles and responsibilities for responding to and troubleshooting issues that arise:

- The City will respond to and diagnose traffic signal operational issue.
    - If issue related to internal signal controller, the City will correct the issues
    - If issue related to hardware/construction, the City will contact the Contractor, or traffic signal subcontractor, to correct the issue.
- The Contractor shall be responsible for intersection hardware, including the equipment within the cabinet.
- The City will be responsible for cabinet software, including traffic signal controller, signal timings, MMU and communications switch.
- The City will be responsible for existing fiber cable locates not installed by the project.
- The Contractor shall be responsible for electrical locates and fiber communications locates installed as part of the project.
- The Contractor shall be responsible for moving detectors and reprogramming detection zones based on the needs of the project.