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Iowa Department of Transportation

SPECIAL PROVISIONS

FOR

TRAFFIC SIGNAL AND INTERCONNECT

Pottawattamie County
IM-080-1(326)2--13-78

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THE STANDARD SPECIFICATIONS, SERIES 2001, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

INDEX

A. NEMA TS 2 ACTUATED TRAFFIC SIGNAL CONTROLLER UNIT

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

The local intersection Controller shall be functionally compatible with and interlinkable with local intersection Controllers installed on US 275 in Council Bluffs, Iowa. The signal system shall also be capable of operating as a Closed Loop System, which shall be compatible with the City of Council Bluff's existing MARC 360 Closed Loop System manufactured by Eagle Signal Controls. The Controller shall be the EPAC3708M52 of the Eagle EPAC M50 series with single mode fiber optic modem produced by Siemens. The City Traffic 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 manufacture the cabinet terminal facilities. All other equipment may be multi-source. Refer to NEMA Standard TS2, Type 2 – 1992 for further standards and specifications for TS2 signal equipment.

1 INTRODUCTION

This specification sets forth the minimum requirements for a shelf-mountable, two to sixteen phase, actuated, digital, solid-state traffic controller unit. The controller unit shall meet, as a minimum, all applicable sections of the NEMA Standards Publication. No. TS 2-1992.

Where differences occur, this specification shall govern. Controller versions shall be available to comply with NEMA TS 2 Types 1 and 2. Type 2 versions of the controller shall be capable of operating as a Type 1.

2 HARDWARE

2.1 ENCLOSURE

2.1.1 The controller shall be compact so as to fit in limited cabinet space. It shall be installable on a shelf that is not more than 7 inches deep. External dimensions shall not be larger than 10 inches in height by 16 inches in width by 10 inches in depth.

2.1.2 The enclosure shall be constructed of sheet metal and shall be finished with an attractive and durable protective coating.

2.1.3 The controller unit shall be of modular design. The enclosure shall be designed for easy access during maintenance, allowing for ease of testing without requiring disassembly or extender boards.

2.2 ELECTRONICS

2.2.1 The electronics shall be modular and shall consist of vertical circuit boards.

2.2.2 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 set an output to FALSE and indicate an error message if a pulse is not received from the microprocessor within a defined period.

2.2.3 In the interest of reliability, sockets shall only be used for components with 20 pins or more.

2.2.4 A built-in, high-efficiency power supply shall generate all required internal voltages. All voltages shall be monitored with control signals. All fuses, connectors and controls shall be mounted on the front of the controller unit.

2.2.5 Timing of the controller shall be derived from the 120 VAC power line. A 10 year lithium battery shall maintain the time-of-day clock and digital data during a power outage lasting up to 30 days. Lead-acid, nickel-cadmium, or alkaline batteries shall not be acceptable.

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

a. All plated-through holes and exposed circuit traces shall be plated with solder.

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

c. The circuit reference designation for all components and the polarity of all capacitors and diodes shall be clearly marked adjacent to the component. Pin 1 for all integrated circuit packages shall be designated on all printed circuit boards.

d. All electrical mating surfaces shall be gold-plated.

2.3 FRONT PANEL & CONNECTORS

2.3.1 The front of the controller shall consist of a panel for the display and keyboard plus a separate panel for the connectors.

2.3.2 An 8-line by 40-character/line alphanumeric liquid crystal display (LCD) shall show program and status information. The display area shall have nominal measurements of 1 1/2 inches in height by 5 1/4 inches in width or larger. For ease of viewing, backlighting and multiple levels of contrast adjustment shall be provided.

2.3.3 Front-panel operator inputs shall be via clearly labeled and environmentally sealed keys. These shall include a 12 position (0-9, plus * and #) telephone-type keypad, four-arrow cursor control keys plus four additional keys (E, F, + and -).

2.3.4 The following interface connectors shall be accessible from the front of the controller:

a) Type 1 Controller Unit Only: Connector A - mate with MS3106()-18-1S
   Type 2 Controller Unit Only: Connector A - mate with MS3116()-22-55S
   Type 2 Controller Unit Only: Connector B - mate with MS3116()-22-55P
   Type 2 Controller Unit Only: Connector C - mate with MS3116()-24-61P
b) Port 1 SDLC - 15 pin metal shell D subminiature (female contacts)
c) Port 2 RS 232 - 25 pin metal shell D subminiature (female contacts)
d) Port 3 – Fiber modem (multimode)

2.4 SERVICEABILITY

2.4.1 All electronic modules other than the power supply shall be easily removable from the front of the controller using a standard screwdriver as the only tool. All power and signal connections to the circuit boards shall be via plug-in connectors.

2.4.2 The controller layout shall allow the removal and replacement of any circuit board without unplugging or removing other circuit boards. No more than two boards shall be attached together to form a circuit assembly. Attaching hardware shall use captive screws or 1/4 turn fasteners to secure circuit assemblies to the enclosure.

2.4.3 The controller enclosure shall allow complete disassembly using a standard screwdriver. It shall be designed so that one side of any circuit board is accessible for troubleshooting and testing while the controller is still in operation. This capability shall be accomplished without the use of extender cards or card pullers.

3 OPERATING DISPLAYS

3.1 The dynamic displays listed below shall be provided to show the operational status of the controller. Additional displays shall be offered for programming.

3.1.1 An intersection status display shall indicate the active status of all signal driver outputs and vehicle plus pedestrian calls. When this display is active, vehicle and/or pedestrian calls may be placed from the keyboard.

3.1.2 An active timer display shall show a summary of ring, phase, coordination, pre-emption and time-based control status. The menu shall provide for the selection of any combination of the rings for display (R1 + R2, R3 + R4, R1 + R3, etc.).

This active timer display shall indicate current interval, pedestrian, density, passage, and maximum timing by phase and ring. The status of vehicle and pedestrian phases shall be displayed in combination with vehicle and pedestrian calls. Operational modes shall also be displayed e.g. Time Base, Interconnected, System, Backup, Manual, System Flash, Start Flash, Stoptime, Preempt, Priority, TS2 Diagnostic Flash, etc.

When this display is active vehicle and/or pedestrian calls may be placed from the keyboard.

3.1.3 A coord timer's display shall allow viewing of the real time status of coordination timer(s) and parameters for the active pattern. Indicate the command source, current pattern information, local/system cycle count, offset mode, offset correction, time-based control status, coord mode, max mode, force-off mode, phase pattern & mode and permitted phase & control data.

3.1.4 A preempt timers display shall indicate preemption (railroad, fire, emergency) and low priority (bus) status. When a preemptor is active, the display shall also indicate preemptor interval and timer countdown as well as priority lockout and max call time out.

3.1.5 A time base status display shall indicate the current time and date, the current day and week program, the active programmed selections of the coordination pattern and auxiliary functions.

3.1.6 A communications status display shall indicate the current status of communications on Port 2 (RS232 connector) and Port 3 (systems interface connector). The display shall include the settings (speed, data bits, parity and stop bits) programmed for each port.

3.1.7 A detector status display shall indicate the current status for up to 80 detectors. The display shall show the status as determined by the detector diagnostics capability of the controller. The condition will be reported as one of the following states: on-line, failed open loop, failed shorted loop, failed excessive inductance change, failed max presence diagnostic, failed no activity diagnostic, failed erratic counts diagnostic, BIU frame fault, not supported or "LWD" (not TS2 detector, detector failure or detector watchdog timeout).

3.1.8 A Port 1 frames display shall indicate the data content of any Port 1 frame in a 'bit' format to enable the user to analyze the content of any SDLC frame.

3.1.9 An Input / Output display shall indicate the current status of any NEMA TS 2 Type 2 Controller Unit input or output.

3.1.10 A MMU display shall indicate the current status of the MMU all channel RYG inputs and up to six (6) faults simultaneously.

3.1.11 A Message display shall be provided to enable 6 lines of text (40 characters per line), which may be downloaded from the system master and displayed.

4 PROGRAMMING

4.1 PROGRAMMING DISPLAYS

4.1.1 Programming displays in the form of menus shall aid the operator in entering data from the front-panel keyboard.

4.1.2 A main menu shall allow the user to select a major function of the controller. A submenu shall then be displayed to allow the user to select a sub-function within the major function. A four-arrow cursor key shall allow the user to scroll through all menus and submenus.

4.1.3 English language and traffic engineering terminology shall be used throughout to facilitate programming. The display organization shall allow traffic personnel to program the controller without using reference cards or manuals.

4.1.4 Programming entries shall consist of alpha or numerical values. During program entry, the new data shall be displayed as it is entered. Entries shall only be validated and stored when the ENTER ("E") key or the cursor key is pressed.

4.2 PROGRAMMING METHODS

4.2.1 The methods listed below shall be available for controller programming. The manufacturer shall be able to provide as off-the-shelf items all of the firmware and software required to affect the listed programming methods and to implement network operation with system masters and host PC's.

a. Manual data entry via the front panel keyboard.

b. Data downloading via telemetry from a system master connected to a host PC in a closed-loop system.

c. Data downloading from a portable PC-compatible computer via null-modem cable.

d. Data downloading from a PC-compatible computer via modem.

e. Data downloading from one controller to another using a serial port on each controller.

4.3 PROGRAMMING SECURITY

4.3.1 The controller unit shall prevent the alteration of keypad set unit variables prior to the user having entered a specific code. No access code shall be required to display data. Access codes shall initially be set at "0000". Entry of a code of "9999" prevents access from being turned off.

4.4 PROGRAMMING UTILITY FUNCTIONS

4.4.1 A copy function shall permit copying all timing data from one phase to another. It shall also permit copying all coordination pattern data from one pattern to another. This feature will facilitate data entry when programming any two or more phases with the same timing values and/or two or more coordination patterns with the same pattern data.

4.4.2 The controller unit shall contain a backup database stored in nonvolatile memory. A copy function shall permit transferring the backup database to the active database. An alternate database for interchange control operation shall be selectable from the keyboard.

4.4.3 The controller shall be capable of communicating via the Port 2 and Port 3 RS-232 interfaces. The Port 2 and Port 3 configuration shall provide user selection of baud rate (1200, 2400, 4800, 7200, 9600, & 19200).

4.4.4 A print function shall allow the printing of controller unit data and detector count, detector failure and event logs. The controller shall be capable of interfacing with any printer with an RS-232 interface and capable of a minimum width of 80 columns. The printer configuration shall provide user selection of baud rate (1200, 2400, 4800, 7200, 9600, & 19200), data bits (7 or 8), and parity (odd, even, and none).

4.4.5 TS 2 Type 2 Controller Units shall provide a keyboard entry for 'ABC I/O' modes that override the selection via the 'mode' inputs to insure a cabinet wiring fault will not cause the interpretation of the inputs to change.

4.4.6 A display shall be provided to allow the user to view the controller software version number.

4.4.7 A display shall be provided to assist the user in programming the MMU Programming card based on the controller unit ring structure and overlap programming.

5 ACTUATED CONTROL FUNCTIONS

The controller shall provide all actuated control functions and operations required by the NEMA TS2 Standard. In addition, it shall provide the features described in the following paragraphs.

5.1 PHASE SEQUENCE

5.1.1 The phase sequence of the controller shall be programmable in most any combination of sixteen phases and four timing rings.

5.1.2 Phase sequence information shall be changeable from the keyboard and stored in EEPROM data memory.

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

5.1.4 The controller unit shall provide an adaptive protected/permissive sequence capability, which measures the volume of left turn vehicle traffic and available gap windows in the opposing through vehicle traffic to determine whether the turn should operate in protected or permissive mode.

5.1.5 The controller unit shall provide the ability to inhibit service of a phase based on another phase being ON via keyboard entry.

5.1.6 The controller unit shall provide control of five-section, protected/permissive left turn heads. When selected, this feature shall cause the through (even) phase yellow to inhibit display of the left turn (odd) phase yellow.

5.2 TIMING INTERVALS

5.2.1 Timing intervals shall be programmable from 0 to 999 in one second increments or from 0 to 99.9 in one-tenth second increments, depending on the function.

5.2.2 Guaranteed minimum interval values of 3.0 seconds shall be set for all yellow clearance timings (normal and preempt routines).

5.2.3 Cars before reduction shall provide a user-specified number of actuations, or cars waiting, that must occur before starting gap reduction. Gap reduction shall be initiated by either time before reduction or cars before reduction; whichever reaches its maximum value first.

5.2.4 The controller unit shall be capable of alternate passage/maximum timings for each phase. Up to three alternate passage timings and maximum green timings shall be selectable based on time of day.

5.2.5 The controller shall be capable of dynamically extending the maximum green time for each phase based on vehicle demand. Up to three dynamic maximum green intervals shall be selectable per phase based on time of day. The initial interval shall be selectable as either Max 1 or Max 2. If the phase terminates due to max out for two successive cycles, then the maximum green time in effect shall automatically be extended by one dynamic step interval on each successive cycle until it is equal to the selected Max. If the phase gaps out for two successive cycles, then the maximum green time shall be reduced by one dynamic step

interval until such subtraction would mean the adaptive max was less than the smaller of the normal max or the dynamic max, value.

5.3 OVERLAPS

5.3.1 The controller shall provide sixteen internally generated overlaps (A through P). These shall be individually programmable.

5.3.2 Each overlap shall be individually programmable to enable the green to remain on following termination of the parent phase green (trailing operation). The controller unit timing for the trailing operation shall include green (0 to 999 seconds), yellow (0 to 99.9 seconds) and red (0 to 9.9 seconds) timing intervals for each overlap.

5.3.3 Each overlap shall provide an entry (phase number) that will omit the overlap trailing operation when the entered phase is ON.

5.3.4 Each overlap shall provide an entry (phase number) that will omit the overlap trailing operation when the entered phase is NEXT.

5.3.5 Each overlap shall provide an entry (phase number) that will prevent the overlap from outputting a green when the entered phase is outputting a green and outputting a yellow when the entered phase is outputting a yellow.

5.3.6 Each overlap shall provide an entry (phase number) that will prevent the overlap from outputting a green until the entered phase is outputting a green.

5.3.7 Overlap functions shall be programmable from the controller keyboard.

5.4 CONDITIONAL SERVICE

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

5.5 ADDITIONAL FEATURES

5.5.1 The following features shall be programmable for each phase:

a. Phase in use
b. Locking/non-locking detector memory
c. Vehicle recall (Minimum, Maximum, and Soft)
d. Pedestrian recall
e. Recall Delay

5.5.2 Soft recall shall return the controller unit to the programmed phase when a conflicting phase is in green or red dwell and there are no serviceable conflicting calls.

5.5.3 Recall delay shall cause the programmed recall (min, max, soft, and ped) to occur the programmed seconds (0 to 999) after the phase termination.

5.5.4 The controller shall permit power-up start and external start to be programmed by phase and interval. Start intervals shall be green, yellow or red.

5.5.5 During a power-up start condition, the controller shall be capable of timing an all-red or flash interval before the start phase(s) and interval are displayed.

5.5.6 The controller shall provide last car passage operation on a per phase basis. When selected, this feature shall provide a full passage (vehicle extension) interval when a phase gaps out with a gap in effect less than the vehicle extension interval (preset gap).

5.5.7 The controller shall provide both single and dual entry operation. When selected, dual entry shall cause the controller to ensure that one phase is timing in each ring.

5.5.8 The controller shall provide the following additional selectable pedestrian functions:

a. Actuated phase Rest In Walk.
b. Flashing WALK output.
c. Pedestrian Clearance protection during manual control.
d. Pedestrian Clearance through yellow or through yellow and red clear.

5.5.9 The controller shall provide a programmable simultaneous gap termination feature. When programmed, phases in both rings shall gap out together in order to terminate the green interval and cross the barrier.

5.5.10 The controller shall provide automatic flash selection per the requirements of the MUTCD. Both the flash entrance and exit phases shall be programmable through the keyboard, and flashing shall be controlled by either setting the voltage monitor output to be FALSE or by flashing through the load switch driver outputs. Automatic flash shall be selectable by external input, system command, or time of day.

5.5.11 The controller shall provide dimming for selectable load switch outputs. Dimming shall be accomplished by inhibiting the selected outputs for alternate half cycles of the 120 VAC line. Dimming shall be controllable by time of day and an external input. Programming shall permit individual dimming of the Green/Walk, Yellow/Ped Clear, Red/Don't Walk outputs for each load switch.

6 COORDINATION

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

6.1 COORDINATION MODES

The normal coordination mode shall be selectable via keyboard entry. Each pattern shall be capable of overriding the normal coordination mode with an individually selectable coordination mode for that pattern.

6.1.1 Permissive Mode - The coordinated phase(s) shall operate as non-actuated when coordinated. The coordinator shall provide for a controlled release (permissive period) from the coordinated phase(s) to each of the remaining phases in sequence. When a call is not present for the phase to be serviced next in sequence, the coordinator shall re-allocate that phase's time to the end of the coordinated phase.

The first part of each permissive period shall consist of a vehicle permissive period. The length of the period shall be determined by the phase split and the vehicle minimum service time.

The second part of each permissive period shall consist of a pedestrian permissive concurrent with the vehicle permissive. The length of this period shall be determined by the phase split and the pedestrian minimum service time.

Prior to the beginning of the first permissive period, the coordinated phase pedestrian shall display the Pedestrian Clear indication and dwell Don't Walk. This will expand each subsequent phase permissive due to the absence of coordinated phase Pedestrian Clear time in each. The coordinated phase pedestrian shall dwell Don't Walk until such time as the coordinated phase terminates and returns to Green or the last permissive period in the cycle is complete without the coordinated phase terminating.

6.1.2 Yield Mode: The coordinated phase(s) shall operate as non-actuated when coordinated. The coordinator shall provide for a single release from the coordinated phase(s) to the remaining phases in sequence.

6.1.3 Permissive Yield Mode: The operation shall be similar to Permissive Mode above with the following exceptions:

1. The coordinated phase pedestrian shall be actuated.

2. Immediately prior to the first permissive, the coordinator will provide a variable period for the coordinated phase extension (Permissive Yield Point).

3. The amount of coordinated phase extension shall be distributed proportionally.

A limitation shall be set on Sequential Omit mode in that it shall apply only to controller units running with no more than two rings in a cluster.

6.1.4 Permissive Omit Mode: The operation shall be equal to Permissive Yield Mode above except that once the coordinated phase has terminated to service a call, it shall not occur again until after the last phase permissive has terminated or a phase is on that is compatible with the coordinated phase.

A limitation shall be set on Sequential Omit mode in that it shall apply only to controller units running with no more than two rings in a cluster.

6.1.5 Sequential Omit Mode: The operation shall be equal to Permissive Yield Mode with the following exceptions:

1. Sequential Omit Mode provides a phase-by-phase sliding window of service (lifted omit). One and only one phase in a ring will have the omit lifted at any time.

2. Following the Permissive Yield Period, the coordinated phase shall be omitted until the last permissive is over.

3. Following the Permissive Yield Period, the opening of a permissive shall occur concurrent with the closing of the prior permissive. The closing of each permissive shall occur at its normal position in the cycle.

A limitation shall be set on Sequential Omit mode in that it shall apply only to controller units running with no more than two rings in a cluster.

6.1.6 Full Actuated Mode: The operation shall be as defined in Permissive Yield Mode with the following exceptions:

1. Following the Permissive Yield Period, any phase may be served in the standard Sequence provided the permissive period for that phase has not expired.

2. Following the Permissive Yield Period, any phase may be reserviced in the standard sequence provided the permissive period for that phase has not expired.

3. Following the Permissive Yield Period and prior to the end of the permissive for the phase before the first coordinated phase, the coordinated phase shall operate as an actuated phase.

A limitation shall be set on Full Actuated mode in that it shall apply only to controller units running with no more than two rings in a cluster.

6.2 A minimum of 16 Timing Plans (Dial/Split) shall be provided. The Timing Plans shall be selected using telemetry (system), hardwire, or non-interconnected (time base) commands.

6.3 CYCLE LENGTH

6.3.1 One cycle length shall be provided for each Timing Plan. The cycle shall be adjustable over a range of 30 to 999 seconds in 1 second increments.

The cycle time of each Timing Plan should be equal to the sum of the phase times of the longest path between barriers in all rings in the controller.

6.4 SYNCHRONIZATION

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

6.4.2 For hardwire systems with multiple sync pulses, the coordinator shall lock onto the correct sync by checking for reoccurrence based on the running cycle length.

6.4.3 After a valid system sync pulse has been received the coordinator shall check for the proper occurrence of the system sync pulse during each subsequent cycle. If a sync pulse does not occur for two consecutive cycles, the coordinator shall revert to "sync monitor free" operation (may be replaced by a TBC event).

6.5 OFFSET

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

6.5.2 Offsets shall be programmable in seconds. The range shall be from 0 to 999 seconds in 1 second increments. The coordinator shall provide three offsets per Timing Plan.

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

6.6 SPLIT

6.6.1 Each split shall provide a split interval for each phase. The split interval shall be programmable using seconds. The range shall be from 0 to 400 seconds in 1 second increments.

6.6.2 Split interval settings shall determine the maximum time, including vehicle clearance (yellow and red), for a non-coordinated phase, or the minimum time for a coordinated phase.

6.6.3 The controller unit shall provide a 'fixed' forced mode that terminates a phase based on the plan timing via keyboard entry. Each phase shall be forced the split time after it becomes active to enable all unused time phase by phase to the beginning of the coordinated phase.

6.6.4 The controller unit shall provide a 'floating' force mode that terminates a phase based on the cycle timing via keyboard entry. Each phase shall be forced at a fixed position in the background cycle to enable unused time phase by phase to the next phase that has vehicle traffic that is capable of taking it.

6.6.5 The controller unit shall provide the ability, via keyboard entry, to inhibit the internal maximum green timing from terminating a phase during coordinated operation or force the concurrent operation of Maximum Green 1/Maximum Green 2 during coordinated operation.

6.7 TRANSITION CYCLES

6.7.1 The controller shall provide a smooth and orderly transition when changing from free operation to coordinated operation and from one coordination command to another.

6.7.2 During a free-to-coordinated transition, the controller shall initiate a pick-up cycle beginning upon receipt of a valid coordination command. The controller shall then enter coordination mode at the beginning of the coordinated phase greens.

6.7.3 Each coordination command shall select a cycle, offset and split. Cycle, offset and split changes shall not take effect until local zero.

6.8 ABSOLUTE SYNC

6.8.1 The controller unit shall provide a sync reference method in which each cycle will be individually referenced to a single point in time via a keypad initiated command or downloaded via the system interface or RS232 port. This operation shall allow the controller unit to keep in step with a free running cycle counter, particularly one which does not divide evenly into 24 hours, such as a 70 second cycle.

Following a power outage, the controller unit shall automatically update the absolute sync reference points. The controller unit shall be capable of updating the reference points following a power outage of up to seven days without being reset.

6.9 LOCAL SPLIT DEMAND

6.9.1 The coordinator shall provide a minimum of two queue selection routines (four detectors per routine assigned from system detectors), which shall allow the selection of a preferred coordination pattern based upon intersection demand.

6.9. 2 The queue routines shall be capable of selecting tasks other than patterns when the demand level exceeds the thresholds. As a minimum, the alternate passage/ maximum operation and adaptive maximum operation as specified above shall be selected via the queue routines.

6.10 FREE MODE

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

6.10.2 Free mode operation shall be selectable by coordination commands, by external input or by keyboard entry.

6.10.3 The coordinator shall revert to the free mode when active controller inputs or functions would interfere with coordination. Such inputs or functions shall include the following:

a. Manual control enable
b. Stop time
c. Automatic flash
d. Preemption

6.11 MANUAL CONTROL

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

6.12 INTERCONNECT MODES

6.12.1 The coordinator shall be capable of operating with any of the following interconnect types:

a. Telemetry
b. Non-interconnected coordination (time-based)
c. Hardwired

6.12.2 The coordinator shall be compatible with fixed-time interconnect, which provides the sync pulse superimposed on the offset lines. The non-interconnected coordination mode shall serve as a backup when using telemetry or hardwired interconnect.

6.13 MASTER COORDINATOR

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

6.13.1 The controller unit shall provide a user selectable option of interrupter sync pulses on the active offset output. Interrupter sync pulses shall provide the true sync pulse plus additional pulses at intervals equal to 20% and 25% of the cycle on alternate cycles.

7 <u>PREEMPTION</u>

The controller shall provide a minimum of six preemption sequences. Preemption capability shall be standard and shall not require additional modules or software.

7.1 RAILROAD-FIRE-EMERGENCY VEHICLE PREEMPTION

7.1.2 The six preemptors shall be selectable as to priority one to another and any preempt to automatic flash.

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

7.1.3 Preemptor timing intervals shall be programmable from 0 to 999 in 1 second increments or 0 to 9.99 in 1/10 second increments, depending on function.

7.1.4 A programmable delay time interval shall be provided to inhibit the start of the preemption sequence. This time shall be programmable from 0 to 999 in 1 second increments. This interval shall begin timing upon receipt of a preemption call.

7.1.5 A programmable extend time shall be provided to stretch the call duration from the point of termination of the actuation. This time shall be programmable from 0 to 999 in 1 second increments.

7.1.6 A programmable duration time shall be provided to control the minimum time that a preemptor remains active. This time shall be programmable from 0 to 999 in 1 second increments.

7.1.7 A programmable maximum call time shall be provided to control the maximum time that a preemptor remains in control. This time shall be programmable from 0 to 999 in 1 second increments. The preemptor maximum call time interval shall be inhibited when set to zero.

7.1.8 A programmable lockout time shall be provided to prevent entering a Low Priority routine following exit from preempt. This time shall be programmable from 0-999 in one second increments. If a lockout time has not been entered (zero entry) then all phases with a call when leaving the sequence shall be serviced before the low-priority routine may be serviced.

7.1.9 Signal displays in effect at the beginning of a preemption sequence shall not be terminated unless the respective green/walk has been in effect for a minimum time. If the respective green/walk has been active for longer than the programmed minimum GREEN/WALK time, the controller unit shall immediately advance to the next interval. Minimum times shall be programmable for the GREEN/WALK interval on a per ring basis. This time shall be programmable from 0 to 999 in 1 second increments.

7.1.10 A phase shall advance to pedestrian clearance if it has timed the minimum GREEN/WALK interval at the beginning of a preemption sequence. The programmed preempt pedestrian clearance will then be timed. During preemption, Track Green and Dwell, pedestrian signals shall be individually selectable as being a solid DON'T WALK, solid WALK, flashing WALK, OFF (blank), or cycling (dwell).

7.1.11 During preempt, Track Green and Dwell, vehicle signals (phase and overlap) shall be individually selectable as being a solid Red, solid green, flashing Red, flashing Yellow, or cycling (dwell).

7.1.12 Each preemptor shall provide user-programmable Track Green and Dwell intervals with appropriate clearance intervals.

7.1.13 During the track green period, the preemptor shall time the track green, yellow and red intervals once, and then advance to the dwell interval. If track green timing is not selected (Track Green set to zero) the track green and clearance intervals shall be omitted from the preempt sequence.

7.1.14 The preemption dwell interval shall remain in effect until the preemptor duration time and dwell times have elapsed and the preemptor call has been removed or the preemptor maximum time has been exceeded.

7.1.15 Exit phases shall be selectable to time after the preemption sequence has been completed. These shall serve as transition phases to return the controller to normal operation. It shall also be possible to place calls on selected phases upon exiting preemption.

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

7.1.17 Preemptor active outputs shall be provided for each of the preemptors. The output shall be set to ON when the corresponding preempt or low-priority routine is in control. Additionally, it shall be possible to program the non-active, preemptor outputs to flash while another preemptor is active. An additional output ("priority active") shall be active when a priority routine is in control.

7.2 LOW PRIORITY ROUTINES

7.2.1 Six low-priority routine routines shall provide control for bus or other low-priority vehicles. The low-priority routines shall be overridden by preempt (railroad-fire-emergency vehicle) calls.

7.2.2 An oscillating signal (1 to 6.25 Hz - pulse-per-second) with a 50% duty cycle shall identify a low-priority call. Low-priority calls shall be capable of call memory and shall be served in the order received.

7.2.3 Low-priority timing intervals shall be programmable from 0 to 999 in 1 second increments.

7.2.4 A lockout time shall be provided to avoid excessive utilization of the same low-priority routine. If a call is received before the lockout time has elapsed, the low priority routine shall not be reserviced. If a lockout time has not been entered (zero entry) then all phases with a call when leaving the sequence shall be serviced before the low-priority routine may be served again.

7.2.5 Low-priority routines shall provide delay, extend, duration, and maximum call time functions similar to those for railroad-fire-emergency vehicle preemptors described above.

7.2.6 The low-priority routine shall advance to the green dwell interval. During this interval, permissive phases shall be selectable to remain green until the dwell time has elapsed and the low-priority routine call has been removed or the preemptor maximum call time has been exceeded.

7.2.7 The low priority routine shall advance to the dwell interval as if Force Off were active. This shall preclude early termination of a Green interval prior to the completion of Minimum Green, Maximum Initial, Walk, or Ped Clear time. The ability to Skip phase(s) during this transition shall be provided as a user option.

7.2.8 It shall be possible to program the controller to allow concurrent phases to be serviced for a low-priority routine with only one phase selected as the dwell phase.

7.2.9 It shall also be possible to place calls on selected phases upon exiting a low priority routine.

7.2.10 Low Priority routines shall not disable or lockout coordination. Coordination shall continue to run during the low priority routine and shall determine the phase(s) to follow based on the current allowed phase(s) in the background cycle.

8 PREEMPTION SAFEGUARDS

8.1 If a preemptor call is active when power is restored to a controller, the controller unit shall maintain the start-up condition for the duration of the preempt input and start-up time. Similarly, if external start is applied during a preemption sequence, the controller shall revert to Start-up rather than the initialization condition. The start-up condition shall remain in effect for the duration of the external start; preempt input and /or start-up time.

9 TIME-BASED CONTROL & NON-INTERCONNECTED COORDINATION

The controller shall include time-based control. This capability shall be a standard feature and shall not require additional modules or software.

9.1 CLOCK/CALENDAR FUNCTIONS

9.1.1 The controller shall provide a time-of-day (TOD) clock, which shall be used for all time-based control functions. The only required clock settings shall be the current time (hour, minute and second) and date (month, day and year).

9.1.2 During normal operation, the TOD clock shall use the power line frequency as its time base. When power is removed, the time shall be maintained by a crystal oscillator for up to 30 days. In the battery backup mode time is maintained to within 0.005% as compared to WWV time standard.

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

9.1.4 The controller shall include a time reset input. This feature shall reset the TOD clock to 04:00:00 whenever the time reset input is TRUE.

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

9.2 TIME-BASED CONTROL

9.2.1 A minimum of 250 different traffic and/or auxiliary events shall be capable of being programmed over a 99 year time frame.

9.2.2 A program day is the list of traffic and/or auxiliary events to occur in a 24 hour period. The TBC program shall provide for 99 program days to be defined.

9.2.3 The normal day-of-week (Sunday through Saturday) event listing will utilize program days 01 through 07 with Sunday being program day 01.

9.2.4 The exceptions to the normal day-of-week event listings (special days) will utilize program days 01 through 99. Program days 01 through 49 will be utilized for special day programs which occur on the same date (month and month day) every year. Program days 50 through 99 shall be utilized for special days, which occur on one date (year, month and month day).

9.2.5 It shall be possible to equate program days, which require the same event listing to effectively multiply the event capacity. It shall be possible to transfer (copy) an entire program day event listing to another program day to permit data editing to create a similar but different program day event listing.

9.3 TRAFFIC FUNCTIONS

9.3.1 The TBC scheduler shall provide for the programming of traffic and auxiliary events to implement non-interconnected coordination. These shall not have to be entered in any special sequence. Each of the traffic events shall permit selection of the following functions:

a. Time of occurrence (Hour, minute and program day)
b. Coordination (TBC pattern or interconnect)
c. Free (No Coordination)
d. Flashing

e. Maximum 2 Timing by phase
f. Phase Omit by phase
g. Ped Omit by phase
h. Maximum Vehicle Recall by phase
i. Minimum Vehicle Recall by phase
j. Pedestrian Recall by phase

9.3.2 Selection of TBC on-line by external input shall allow the coordination pattern selected by the hardwire system to override the current TBC coordination pattern.

9.3.3 When operating in the non-interconnected coordination mode the synchronization point for all cycles shall be referenced to a user selected reference time (hour and minute) or the event time. The sync reference time is that time from which all cycle zeros shall be calculated. The synchronization point for the cycle selected by the current event shall be computed using the present time, sync reference time, and cycle length. The synchronization point shall occur whenever the present time is such that an even number of cycle length periods has occurred since the sync reference time.

9.4 AUXILIARY FUNCTIONS

9.4.1 These events shall be separate from the non-interconnected traffic events described above. Auxiliary events shall not have to be entered in any special sequence. Each of the events shall permit selection of the following functions:

a. Day program assignment
b. Start time
c. Auxiliary outputs
e. Dimming
f. Detector logging
g. Detector diagnostic plan
h. Control of eight special functions

9.5 TIME OF YEAR FUNCTIONS

9.5.1 The controller unit shall be capable of implementing exception day programs and alternate week programs on a Month, Month Day, and Year basis. A minimum of nine alternate week programs shall be capable of being defined.

10 <u>DETECTOR FUNCTIONS</u>

10.1 The controller shall provide a minimum of 72 vehicle detector inputs. Each input shall be assignable to any phase and be programmable as to detector function. Extend and delay timing shall be provided for each detector.

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

10.3 Each vehicle detector shall be user-programmable to operate as one of the following seven detector types:

a. **Type 0 (VEH):** Detector shall operate as a standard detector providing one call per actuation.

b. **Type 1 (PED):** The detector input operates as a standard pedestrian detector.

c. **Type 2 (ONE):** The detector input operates, as a vehicle detector that is operational while the phase is not green until a call is received on the assigned phase.

d. **Type 3 (SBA):** Detector shall operate as follows: Vehicle calls shall be accepted only when the phase is not green. When a call is detected, it shall be held until the detection area is empty. The extend timer shall begin timing with the phase green. Once the extend timer times-out or the detection area is empty, no further calls shall be accepted until the phase is again not green.

e. **Type 4 (SBB):** Detector shall operate as follows: Vehicle calls shall be accepted only when the phase is not green. When a call is detected, it shall be held until the detection area is empty (if the extend timer is set to zero). The extend timer shall begin timing with the phase green. If a call is received before the extend timer has timed-out, the timer shall be reset. Timer reset shall occur until a gap between the calls is large enough to allow the extend timer to time-out. Once time-out has occurred, no further calls shall be accepted until the green terminates.

f. **Type 5 (PPL):** The detector input operates as a turn vehicle detector Adaptive Protected/Permissive routine.

g. **Type 6 (PPT):** The detector input operates as a through vehicle detector Adaptive Protected/Permissive routine.

10.4 Each detector input shall be capable of functioning as one of eight system detectors.

10.5 Vehicle detectors shall be capable of being assigned to a minimum of two speed trap detector sets. Speed shall be detected using a two-detector configuration. Speed shall be computed using a keyboard entered loop spacing distance of 11 feet or 22 feet.

10.6 The controller shall provide a minimum of eight hardware denoted pedestrian detector inputs. Each pedestrian detector shall be assignable to any phase.

11 SYSTEM COMMUNICATIONS

11.1 The controller shall be capable of communicating with an on-street system master or directly to a central office computer-based system master. A separate telemetry module shall provide this capability, which shall be included in the controller when required by the plans and specifications. The telemetry module shall receive system commands and data transmissions. In addition, it shall transmit the controller status, database and system detector information to the system master.

11.2 SYSTEM COMMANDS

11.2.1 The telemetry module shall allow the controller to receive, as a minimum, the following commands:

a. Cycle, offset, and split (coordination pattern)
b. Timing parameter downloading and verification
c. Special function commands (minimum of eight)
d. Coordinated, Free, standby and flash mode commands
e. Time and date
f. Request for local status

11.2.2 In the absence of being polled by the master, within a user-defined period (1 to 255 minutes), the local will revert to backup TBC and coordination mode. When again polled by

the master the local will return to the system mode and transition to the master-called program.

11.3 STATUS DATA

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

a. Green and yellow status for all phases and overlaps
b. Walk and pedestrian clearance status for all phases
c. Vehicle and pedestrian detector status
d. Phase termination status
e. Local time
f. Coordination status
   (1) Command source
   (2) Sync or transitioning status of coordinator
g. Conflict flash status
h. Local flash status
i. Automatic flash status
j. Local Free
k. Preempt activity and calls
1. Volume and occupancy data from a minimum of 8 system detectors
m. Speed data from a minimum of two speed detectors
n. Status of six user-defined alarms

11.4 UPLOAD/DOWNLOAD CAPABILITY

11.4.1 The telemetry module shall provide the capability to upload/download the entire intersection database.

11.5 TELEMETRY

11.5.1 Telemetry shall utilize TDM/FSK data transmission at 1200 baud over a single pair of wires. These may be leased lines (Type 3002, voice grade, unconditioned) or dedicated cable. Optional fiber optic communications capability shall also be available.

11.5.2 The nominal transmitter output level shall be 0 dbm into a 600 ohm load. The receiver sensitivity shall be 3 to -40 dbm.

11.5.3 There shall be a communications status display to show telemetry activity as follows: on or off line, carrier active or inactive, transmit active/inactive and response returned (ACK or NAK), receive active and data valid or invalid.

12 <u>DIAGNOSTIC FEATURES</u>

12.1 The controller shall include both automatic and operator-initiated diagnostics. This capability shall be a standard feature and shall not require additional modules or software.

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

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

12.4 DETECTOR DIAGNOSTICS

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

12.4.2 A minimum of two detector diagnostic plans shall be provided. These plans shall be selectable on a time-of-day basis. This shall allow varying the detector diagnostic values to correspond with changes in detector activity.

12.4.3 If a detector is diagnosed as failed, the associated phase shall be placed on minimum recall until such time as the detector is classified as "on-line".

12.4.4 Diagnostics for NEMA TS2 detectors connected to the controller using a Bus Interface Unit (BIU) shall also include detection of watchdog, open and shorted loop, and excessive inductance change failures.

13 LOGGING FEATURES

The controller shall be capable of logging and reporting activity, failures, and the occurrence of selected events or alarms.

13.1 COMMUNICATIONS FAULT LOGGING

13.1.1 The controller shall include a communications fault log capable of storing a minimum of 60 time and date-stamped communications fault events. Once logged, communications fault events shall remain in the log until cleared or the log capacity is exceeded at which time the oldest communications fault events shall be overwritten.

13.2 DETECTOR HISTORY LOGGING

13.2.2 The controller shall include a detector history log capable of logging raw and average volume and raw and average occupancy for up to eight system detectors. The log shall be capable of storing a minimum of 96 time and date stamped detector history events. Once logged, detector history events shall remain in the log until cleared or the log capacity is exceeded at which time the oldest detector history events shall be overwritten.

13.2.3 The detector logging shall be controlled as TBC programmed events.

13.3 DETECTOR FAULT LOGGING

13.3.1 The controller shall include a detector fault log capable of storing a minimum of 60 time and date stamped detector fault events. Once logged, detector fault events shall remain in the log until cleared or the log capacity is exceeded at which time the oldest detector fault events shall be overwritten.

13.3.2 All detector diagnostic faults shall be recorded in the detector fault log including: no activity, maximum presence, erratic counts, watchdog failure, open loop, shorted loop, and excessive inductance change. If a detector recovers after a diagnostic fault, a detector on-line event shall be stored in the detector fault log.

13.4 EVENT LOGGING

13.4.1 The controller shall include an event log capable of storing a minimum of 120 time and date stamped events or alarms. Once logged, events shall remain in the log until cleared or the log capacity is exceeded at which time the oldest events shall be overwritten.

13.4.2 At a minimum the following events shall be logged: communication failures, coordination faults, MMU and local flash status, preempt, power ON/OFF, low battery, data change (from keyboard), data change (from remote), processor faults, EPROM and EEPROM diagnostic faults, invalid TS2 configuration. Up to 86 different messages shall be available. An event shall be logged when an event or alarm returns to normal status.

13.5 MOE LOGGING

The controller unit shall capture information on a coordination cycle-by-cycle basis noting:

a. Volume (Per cycle average number of actuations)
b. Stops (Per cycle average number of actuation received during the non-green time of the phase)
c. Delay (Per cycle average time of the delay on each phase delay accumulates based on cars waiting and elapsed time)
d. Utilization (Per cycle average green time used on each phase)

The above information shall be included in a moe log capable of storing a minimum of 24 time and date stamped moe events. Once logged, moe events shall remain in the log until cleared or the log capacity is exceeded at which time the oldest moe events shall be overwritten.

13.6 SPEED LOGGING

The controller unit shall capture the average speed trap speed for the duration a coordination pattern is active for inclusion in a speed log capable of storing a minimum of 24 time and date stamped speed events. Once logged, speed events shall remain in the log until cleared or the log capacity is exceeded at which time the oldest speed events shall be overwritten.

13.7 CYCLE MOE LOGGING

The controller unit shall capture coordination information on a cycle by cycle basis for each noting the force status, green utilization plus/minus from split, and whether there was an offset correction in that cycle for inclusion in a cycle moe log capable of storing a minimum of 60 time and date-stamped cycle moe events. Once logged, cycle moe events shall remain in the log until cleared or the log capacity is exceeded at which time the oldest cycle moe events shall be overwritten.

13.8 MMU FAULT LOGGING

The controller unit shall capture channel and fault status as reported by the MMU is Port I Response Frame 129 for inclusion into a MMU fault log capable of storing a minimum of 24 time and date stamped MMU fault events. Once logged, MMU fault events shall remain in the log until cleared or the log capacity is exceeded at which time the oldest MMU fault events shall be overwritten.

13.9 VOLUME COUNT LOGGING

The controller unit shall be capable of using up to 24 vehicle or pedestrian detector inputs for a Volume Count log capable of storing a minimum of 72 time and date stamped Volume Count Events. Once logged, Volume Count Events shall remain in the log until cleared or the log capacity is exceeded at which time the oldest Volume Count events shall be overwritten.

The Volume Count Log interval shall be user selectable within the range 0 to 120 minutes. Each Volume Count event in the log shall denote if an assigned detector was diagnosed as failed at any time during the log interval. When a power down occurs in a log interval, all detectors shall be marked as failed to prevent the data being used in error.

B. MALFUNCTION MANAGEMENT UNIT

1 INTRODUCTION

This specification sets forth the minimum requirements for a shelf mountable, 16 channel, solid-state Malfunction Management Unit (MMU). The MMU shall meet, as a minimum, all applicable sections of the NEMA Standards Publication No. TS2-1992. An independent testing laboratory shall verify that the MMU will perform all its defined functions under the conditions set forth in Section 2 of the NEMA STANDARD (Environmental Standards and Test procedures). Where differences occur, this specification shall govern.

2 HARDWARE

2.1 ENCLOSURE

2.1.1 The MMU shall be compact so as to fit in limited cabinet space. It shall be installable on a shelf that is at least 7 inches deep. Overall dimensions, including mating connectors and harness, shall not exceed 10 1/2 inches in height by 4 1/2 inches in width by 11 inches depth.

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

2.2 ELECTRONICS

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

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

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

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

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

2.2.6 All electrical components used in the MMU shall be rated by the component manufacturer to operate over the full NEMA temperature range of +165ºF to -22ºF.

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

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

2.3 FRONT PANEL & CONNECTORS

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

a. Field Check / Dual Enables 1-16
b. Green/Yellow-Dual Indication Enable
c. BND Test Disable
d. External Watchdog Enable

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

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

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

a. Channel Status 1-16
b. Conflict
c. Red Fail
d. CVM / External Watchdog
e. 24V-2
f 24V-1

g. Clearance Fail
h. Port 1 Fail
i. Diagnostic / Program Card
j. Field Check Fail
k. Dual Indication
1. Type 12 mode
m. Power
n. Port 1 Receive
o. Port 1 Transmit

2.4 OPERATING MODES

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

3 MONITORING FUNCTIONS

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

3.1 DUAL INDICATION MONITORING

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

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

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

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

3.1.1 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.

3.1.2 GREEN YELLOW-DUAL INDICATION MONITOR

Green Yellow-Dual Indication monitoring shall detect simultaneous inputs of active Green and Yellow field signal inputs on the same channel. It will be used to monitor channels

which have an unused Red field signal input tied to AC LINE such as a five section signal head.

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

3.2 FIELD CHECK MONITORING

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

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

3.2.1 FIELD CHECK MONITOR

In the Field Check Fault mode, when the field signal input states sensed as active or inactive by the MMU do not correspond with the data provided by the Controller Unit in the Type #0 message for 10 consecutive messages, the MMU shall enter the fault mode, transfer the OUTPUT relay contacts to the Fault position, and illuminate the FIELD CHECK FAIL indicator. The Channel Status Display shall indicate the channels on which the Field Check fault was detected. Bit #67 (Spare Bit #1) of the Type #129 response frame shall be set to indicate a Field Check fault has been detected. The MMU shall remain in the fault mode until the unit is reset by the RESET button or the EXTERNAL RESET input.

3.2.2 FIELD CHECK STATUS

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

3.3 BND ERROR DETECTION MONITORING

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

Detection of a BND Error shall place the MMU into the fault mode, transfer the OUTPUT relay contacts to the Fault position, and illuminate the BND FAIL indicator. The Channel Status display shall indicate the channels on which the fault occurred. When operating in the Type 16 mode with Port 1 communications enabled, Bit #69 (Spare Bit #3) of the Type # 129 response frame shall be set to indicate a BND Error Detection fault has been detected.

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

3.4 EXTERNAL WATCHDOG MONITOR

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

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

3.5 TYPE FAULT MONITOR

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

Detection of a Type Fault shall place the MMU into the fault mode, transfer the OUTPUT relay contacts to the Fault position, illuminate the DIAGNOSTIC indicator, and flash the TYPE 12 indicator at a 2Hz rate. The MMU shall remain in the fault mode until the unit is reset by the RESET button or the EXTERNAL RESET input. An MMU Power Failure shall reset the Type Fault state of the monitor.

4 DISPLAY FUNCTIONS

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

4.1 YELLOW PLUS RED CLEARANCE INTERVAL DISPLAY

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

4.1.1 PORT 1 TRANSMIT INDICATOR

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

4.1.2 PROGRAM CARD INDICATOR

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

5 ADDITIONAL FEATURES

5.1 The MMU shall include both automatic and operator initiated diagnostics.

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

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

C. TS2 TYPE 1 CABINET ASSEMBLY

1 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. TS2-1992. Where differences occur, this specification shall govern. The controller cabinet shall meet the following functional requirements:

2 CABINET DESIGN AND CONSTRUCTION

2.1 The cabinet shall be constructed from type 5052-H32 aluminum with a minimum thickness of 0.125 inches.

2.2 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.

2.2.1 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.

2.2.2 The top of the cabinet shall incorporate a 1 inch slope toward the rear to prevent rain accumulation.

2.3 Unless otherwise specified, the cabinet shall be supplied with a natural aluminum finish. Sufficient care shall be taken in handling to ensure that scratches are minimized. All surfaces shall be free from weld flash. Welds shall be smooth, neatly formed, free from cracks, blow holes and other irregularities. All sharp edges shall be ground smooth.

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

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

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

2.7 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 in thickness by 1.00 inch in width. The gasket material for the police door shall be a minimum of 0.188 inches in thickness by 0.500 inches in width. The gaskets shall be permanently bonded to the cabinet.

2.8 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.

2.8.1 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.

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

2.10 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.

2.11 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.

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

2.13 The main door shall be equipped with a Corbin tumbler lock number 1548-1. Two keys shall be supplied.

2.14 The police door-in-door shall be provided with a treasury type lock Corbin No. R357SGS or exact equivalent and one key.

2.15 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.

2.16 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 in height by 24 inches in width by 16 inches in depth
- Size 5 (M) cabinets: 51 inches in height by 30 inches in width by 16 inches in depth
- Size 6 (P) cabinets: 56 inches in height by 44 inches in width by 24 inches in depth
- Size 7 (R) cabinets: 77 inches in height by 44 inches in width by 24 inches in depth

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.

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

3 TERMINALS AND FACILITIES/MAIN PANEL DESIGN AND CONSTRUCTION

3.1 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.

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

3.3 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.

3.4 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.

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

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

3.7 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.

3.7.1 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.

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

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

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

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

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

3.12 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.

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

3.14 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.

3.15 Terminal blocks for DC signal interfacing shall have a number 6-32 by 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 TS2-1992 Standard document (Section 5).

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

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

*Gauge varies with power panel/main panel set

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

3.18 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.

3.19 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.

3.20 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.

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

3.22 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.

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

3.24 All wire (size 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.

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

4 POWER PANEL DESIGN AND CONSTRUCTION

4.1 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.

4.2 The power panel shall house the following components:

a. A 50 amp main breaker for 12 or 16 position cabinets or a 30 amp breaker for 4 or 8 position cabinets. This breaker shall supply power to the controller, MMU, signals, cabinet power supply and auxiliary panels. Breakers shall be thermal magnetic type, U.L. listed, with a minimum of 10,000 amp interrupting capacity.
b. A 15-amp auxiliary breaker. This breaker shall supply power to the fan, light and GFI outlet.
c. A 50 amp, 125 VAC radio interference line filter.
d. A normally open, 60 amp, mercury contactor for 12 or 16 position or a 35 amp. contactor for 4 or 8 position facilities.
e. A 13-position neutral bus bar capable of connecting three #12 wires per position

5 AUXILIARY CABINET EQUIPMENT

5.1 The cabinet shall be provided with a thermostatically controlled (adjustable between 80 to 150ºF) 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.

5.2 An incandescent lamp and socket shall be mounted in the cabinet to sufficiently illuminate the field terminals. The lamp shall be wired to either a 15 amp ON/OFF toggle switch mounted on the rear cover of the police panel or to a door activated switch mounted near the top of the door.

Alternately, a fluorescent lighting fixture shall be mounted on the inside top of the cabinet near the front edge. The fixture shall be rated to accommodate a F15T8 lamp. The lamp shall be wired to either a 15 amp ON/OFF toggle switch mounted on the rear cover of the police panel or to a door activated switch mounted near the top of the door.

5.3 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.

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

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

5.6 A permanent graphics identification template with a minimum dimension of nine inches by eleven 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 VEHICLE DETECTION

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

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

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

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

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

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

6.6 A cable consisting of 22 AWG twisted pair wires (red and orange) shall be provided to enable connection to and from the panel to a detector rack.

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

6.8 Detectors shall utilize extension and delay timings and be similar to the Eberle Design model LM622 2-channel loop detectors. All card slots shall be filled with detectors. A dual output detector card, Eberle Design model LM632t, shall be used when dual detector outputs are required on the plans.

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

7 CABINET TEST SWITCHES AND POLICE PANEL

7.1 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 intersection shall be placed in flash. The controller shall not be stop timed when in flash. If required by the plans and specifications, an optional RC network shall be provided to give the controller an external start pulse when switch is returned to the auto position. This will force the controller to initiate the start up sequence when exiting flash.
b. STOP TIME SWITCH. When applied, the controller shall be stop timed in the current interval.
c. CONTROL EQUIPMENT POWER ON/OFF. This switch shall control the controller, MMU, and cabinet power supply AC power.

Note: 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.

7.2 The police door switch panel shall contain the following:

a. SIGNALS ON/OFF SWITCH. In the OFF position, power shall be removed from signal heads in the intersection. The controller shall continue to operate. When in the OFF position, the MMU shall not conflict or require reset.
b. AUTO/FLASH SWITCH. In the flash position, power shall not be removed from the controller and stop time shall be applied. If required by the plans and specifications, an optional RC network shall be provided to give the controller an external start pulse when switch is returned to the auto position. This will force the controller to initiate the start up sequence when exiting flash.
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.

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

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

7.5 All switch functions must be permanently and clearly labeled.

7.6 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.

8 CONTROLLER TELEMETRY INTERFACE PANEL

8.1 A telemetry interface harness and interface panel shall be supplied with each cabinet assembly.

8.2 The harness shall be a minimum of 6 feet long and shall consist of two twisted pairs, 22 AWG wire, terminated to a 9 pin "D" type connector at one end. The pin out of the 9 pin connector shall be in exact accordance with the NEMA TS2 Standard. The opposite end of

the harness shall be terminated on a 10 position EDCO PCB- 1 B or exact equal lightning protection socket base.

8.3 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.

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

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

8.5 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.

9 AUXILIARY DEVICES

9.1 LOAD SWITCHES

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

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

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

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

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

9.2 FLASHERS

9.2.1 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.

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

9.3 FLASH TRANSFER RELAYS

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

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

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

9.4 MALFUNCTION MANAGEMENT UNITS

9.4.1 Each cabinet assembly shall be supplied with one Malfunction Management Unit (MMU) as defined by the requirements of Section 4 of the NEMA TS2 Standard.

9.4.2 Malfunction Management Units shall be a Type 16. The MMU shall be an EDI Model MMU-16.

9.5 BUS INTERFACE UNITS

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

9.5.2 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.

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

9.6 CABINET POWER SUPPLY

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

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

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

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

10 TESTING AND WARRANTY

10.1 TESTING

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

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

10.2 WARRANTY

10.2.1 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.

10.2.2 The cabinet assembly and all other components shall be warranted for a period of 1 year.

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

D. TS2 CABINET POWER SUPPLY

1 TS2 COMPLIANCE

This specification sets forth the minimum requirements for a TS2 cabinet power supply that is AC line powered and provides regulated DC power, unregulated AC -power and a line frequency reference for TS2 detector racks, Bus Interface Units, load switches, and auxiliary cabinet equipment. As a minimum, the power supply shall meet all requirements of Section 5.3.5 of the NEMA TS2-1992 Standard plus all other applicable sections of the Standard.

2 MECHANICAL

The power supply shall be compact to fit in limited cabinet space. External dimensions shall not exceed 6 inches in height by 5.75 inches in width by 8.4 inches in depth including connectors and protrusions. The power supply shall be mountable on a shelf or, alternately, be wall-mountable via holes in its rear cover. The power supply enclosure shall be constructed of sheet aluminum.

3 ELECTRICAL

3.1 PRINTED CIRCUIT BOARD

The power supply shall not use more than one printed circuit board. This board shall be made of NEMA FR-4 glass epoxy or equivalent. Exposed circuit traces shall be plated with solder. The designation of all components and the polarity of all capacitors and diodes shall be clearly marked adjacent to the component.

3.2 POWER SUPPLY DESIGN

In the interest of immunity to variations in incoming AC line voltage; the power supply design shall be based on the use of integrated-circuit voltage regulators for the 12 and 24-volt DC supplies.

4 ENVIRONMENTAL

The power supply shall meet all applicable requirements from Section 2 of the TS2-1992 Standard, which covers AC power, temperature, humidity, transients, shock and vibration. These requirements include operation from 89 to 135 VAC power, 60 Hz ± 3 Hz. The operating temperature shall be -30ºF to +165ºF.

5 ELECTRICAL OUTPUTS

Electrical outputs shall be as specified in Section 5.3.5.2 of the TS2-1992 Standard. Outputs shall be as follows:

- +12 VDC ± 1 VDC, 2.0 A
- +24 VDC ± 2 VDC, 2.0 A
- 12 VAC, 0.25 A
- 60 Hz Line Frequency Reference

Regulation of DC outputs within the specified limits and DC ripple not exceeding 0.5 V peak-to-peak shall be maintained over an AC line variation from 89 to 135 VAC and a load variation from 1/8 load to full load. The 12 VAC output shall be referenced to AC Neutral. It shall be unregulated, but shall not be less than 7.5 VAC at 89 VAC power.

The line frequency output shall be False when the 60 Hz line is within its negative half cycle and then source a minimum of 50 mA at nominal 24 VDC. It shall be True when the 60 Hz line is within its positive half cycle and then sink a minimum of 50 mA. The rise and fall times shall be no greater than 50 microseconds when switching a 10,000 pF load capacitance.

6 INPUT & OUTPUT CONNECTIONS

The power supply connector shall be located on the front panel of the power supply. It shall have a metallic shell connected to chassis ground and mate with an MS3106-18-1SW-cable connector or equivalent. Pin terminations shall be as follows:

A AC Neutral
B Line Frequency Reference
C AC line
D **+**12 VDC Output
E +24 VDC Output
F Reserved
G Logic Ground
H Earth Ground
I 12 VAC Output
J Reserved

The AC power input shall be protected against overcurrent with a 2 amp. slow-blow fuse.

7 INDICATORS AND TEST POINTS

Three LED indicator lights shall be provided on the front panel of the power supply to indicate the presence of voltage. Outputs with a matching LED indicator light shall be 12 VAC, 24 VDC and 12 VDC.

Banana jack test points for +24 VDC and Logic Ground shall be provided on the front panel of the power supply.

8 TEST AND WARRANTY

The power supply shall be thoroughly tested to insure compliance with this specification. Upon completion of initial tests, the unit shall be burned in at 74ºC for 48 hours. It shall be re-tested following burn-in.

The power supply shall be warranted to meet this specification at the time of delivery. It shall be warranted by the supplier against mechanical and electrical defects for a minimum period of 1 year from date of delivery. Any defects in design, workmanship or material shall be corrected by the supplier during the warranty period at no cost to the purchaser.

E. ELECTRICAL DESIGN

1 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, cabinet heater, etc. All cabinets housing a Master Unit, video detection equipment or radio transceivers shall be provided with a cabinet heater. The cabinet heater shall be mounted on a winter panel suitable of mounting in place of the cabinet filter assembly. The heater shall be rated at 250 watts and be connected by a twist plug into a receptacle mounted on the bottom right front side panel of the cabinet. The heater circuit shall be provided with a thermostat separate for the cabinet fan thermostat and be settable between 32ºF and - 30ºF. The cabinet fan thermostat shall be settable between 75ºF and 150ºF. The heater shall have a wire mesh shield cover attached to the metal weatherproof cover to block the fan vent assembly. A three-position switch shall be provided to select power to the fan, the heater or select neither. Wiring to the heater shall be stranded copper wire having a 200ºC insulation and be connected using non-insulated solderless terminals. Duplex outlets, which are provided for equipment such as modems and other low current auxiliary equipment, shall also be provided with series-parallel lightning protection. Such outlets will be clearly identified to denote that they are specifically to be used for low current auxiliary electronic equipment only. The surge protector shall be capable of a peak current of 20,000 amps in an 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 at 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 +185ºF to -40ºF. 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.

2 Each signalized location shall utilize a standard 2 pole, weather tight circuit breaker type disconnect. The unit shall be rated a minimum of 60 amps and grounded as per NEC standards. The disconnect shall be electrically located after the battery backup system (BBS).

3 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.

4 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.

5 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.

6 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.

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

8 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.

F. TRAFFIC SIGNAL BATTERY BACKUP SYSTEM (BBS)

1 GENERAL

1.1 A battery backup system (BBS) specifically designed for traffic signals shall be included on all new traffic signal installations. The BBS shall provide reliable emergency power to a traffic signal in the event of a power failure or interruption. The BBS enclosure will be mounted directly to the side of the controller cabinet. At a minimum the batteries shall be housed in the BBS enclosure, if there is adequate space the BBS equipment may be located in the controller cabinet at the contractor's option. The BBS shall be furnished and installed in conformance with the following specifications.

1.2 The BBS shall include the following:

- Inverter/Charger
- Power Transfer Relay (may be internal to the inverter)
- Manual Bypass Switch
- Batteries
- Battery blankets or cabinet heater as required
- All necessary hardware and wiring
- Battery Cable Harness
- O&M Manuals (2 copies)
- Enclosure Cabinet
- Mounting hardware
- Conduit fittings

2 DESIGN/OPERATIONAL REQUIREMENTS

2.1 The BBS shall provide a minimum of 2 hours of full run-time operation for an all LED intersection.

2.2 Minimum 1250VA, 875 watts active output capacity, with 80% minimum inverter efficiency

2.3 The power transfer relay will automatically transfer power to the BBS when line power is interrupted until the line power is reestablished based on the following parameters

2.4 BBS shall automatically bypass the utility line power whenever the utility line voltage is outside of the range 100 VAC to 130 VAC (+/- 2VAC).

2.5 When the utility line power has been restored to between 105 VAC and 125 VAC (+/-2 VAC) for more than 30 seconds the BBS shall automatically transfer from battery backed inverter mode back to utility line mode.

2.6 A maximum recharge time of 6 hours to 95%

2.7 When utilizing battery power, the BBS output voltage shall be between 110 VAC and 125 VAC, pure sine wave output, less than 3%THD, 60Hz +/-3Hz.

2.8 The maximum transfer time allowed, from disruption of normal utility line voltage to stabilized inverter line voltage from batteries, shall be 65 milliseconds. The same maximum transfer time shall also apply when switching from inverter line voltage to utility line voltage.

2.9 Transient voltage protection shall be provided.

2.10 The BBS shall be lightning surge protection compliant with IEEE 587/ANSI C.62.41.

2.11 RS 232 and USB ports for local or remote monitoring.

2.12 Operating temperature for the inverter/charger, power transfer relay and manual bypass switch shall be 0-95% non-condensing humidity; +165ºF to -35ºF.

2.13 Both the power transfer switch and the manual bypass switch shall be rated at 240VAC/30amps, minimum.

2.14 The Manual Bypass Switch shall enable the removal and replacement of the Inverter/Charger without shutting down the traffic control system.

2.15 The BBS shall include a display and/or meter to indicate current battery charge status and condition.

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

2.17 The BBS and batteries shall be easily replaced with all needed hardware and shall not require any special tools for installation.

2.18 All components shall be wired and conform to NEMA, NEC and UL standards.

2.19 Manufacturers shall provide a 2 year factory repair warrant for parts and labor on the BBS from the date of acceptance. Batteries shall be warranted for full replacement for 2 years from date of purchase.

2.20 Manufacturer shall include a set of equipment lists, operation and maintenance manuals, and board-level schematic and wiring diagrams of the BBS and the battery data sheets.

3 BATTERY SYSTEM

3.1 The battery shall be comprised of extreme temperature, deep cycle, sealed, maintenance-free lead acid based AGM/VRLA (Absorbed Glass Mat/Valve Regulated Lead Acid) or comparable.

3.2 Batteries shall be certified by the manufacturer to operate at extreme temperatures from +165ºF to -40ºF.

3.3 The batteries shall be provided with the appropriate interconnect wiring and corrosion resistant mounting trays. Battery terminals shall be covered and insulated with molded boots so as to prevent accidental shorting.

3.4 The battery cable 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.

3.5 Batteries shall include maximum recharge data and recharging cycles.

4 ENCLOSURE CABINET

4.1 Batteries shall be housed in a NEMA 3RX rated cabinet mounted to the side of the controller cabinet. Maximum cabinet dimensions are 48 inches in height by 20 inches in width by 9 inches in depth.

4.2 Cabinet shall be constructed of stainless steel or anodized aluminum with stainless steel hardware.

4.3 The cabinet shall be ventilated through the use of louvered vents, filter, and one thermostatically controlled fan.

4.4 The cabinet shall be factory wired and tested before shipment.

G. ELECTRICAL SERVICE PEDESTAL

1 SERVICE ENCLOSURE

The service enclosure shall be TESCO class 26-100-M-A2 or equal and 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 in width by 43 inches in height and 7 1/2 inches in depth. 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 WIRING SCHEMATICS

2.1 Produce wiring schematics using drafting software. Include all external equipment and

connections in accordance with NEMA IIB. Enclose as-built factory drawings in clear plastic. Store drawings inside the outer door using welded hooks.

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

H. VIDEO VEHICLE DETECTION SYSTEM

1 GENERAL

The video vehicle detection system shall be the Autoscope Solo Terra system. Refer to the latest Autoscope Solo Terra Specification.

1.1 INSTALLATION AND TRAINING

1.1.1 Two days of training shall be provided to personnel of the Contracting Authority in the operation, setup, and maintenance of the video detection system.

1.1.2 Instruction and materials shall be provided for a maximum of 10 persons and shall be conducted at a location selected by the Contracting Authority.

1.1.3 The Contracting Authority shall be responsible for any travel, room, and board expenses for its own personnel.

1.1.4 To ensure that the end-user has complete competency in system operation, proper instruction from factory certified instructors shall be required.

2.1 WARRANTY, MAINTENANCE AND SUPPORT

2.1.1 The video detection system shall be warranted by its supplier for a minimum of 2 years, with an optional three year extended warranty, for an additional fee at the time of initial system purchase, providing availability of a five year warranty package.

2.1.2 Ongoing software support by the supplier shall include software updates of the MVP and application software. These updates shall be provided at no additional charge during the warranty period, provided software registration is completed and returned to the manufacturer, by the end-user, within 30 days of system installation. The supplier shall maintain a program for technical support and software updates following the expiration of the warranty period. This program shall be made available to the Contracting Authority in the form of a separate agreement for continuing support.

I. EMERGENCY VEHICLE TRAFFIC SIGNAL PRIORITY CONTROL SYSTEM

1.0 All new traffic signal systems, installed after May 1, 2007 shall have installed the 3M Corporation Opticom brand of radio activated, GPS based emergency vehicle traffic signal priority control system (Preempt System).

1.1 All equipment and cabling necessary for the operation of the Preempt System shall be supplied and installed by the contractor to 3M specifications.

1.2 Software configuration and system testing of the Preempt System shall be completed by the City Traffic Division personnel.

J. FIBER OPTIC INTERCONNECT

All new signal systems, which are to be interconnected after 5/1/1995 will require fiber optic, interconnect cable. Systems which are being extended or modified from an existing system may use the standard wire interconnect specifications unless specifically noted on the plans.

This work shall consist of furnishing and installing a fiber optic network for a traffic signal Controller 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 between local Controllers and/or the Master shall be furnished and installed as a part of this item. These items shall include but not be limited to the following items:

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 manufacture'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. Only fibers needed to operate equipment plus two spares shall be terminated with ST connectors. All other fibers shall be capped and sealed in accordance with manufacturer's recommendation.

Connectors.
Only ST type connectors of ceramic ferrule and Physical Contact <PC> end finish shall be used to terminate fibers to equipment. ST or mechanical connectors shall not be used to splice cables.

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.

Modems and their power supply.
The term modem is used to refer to the fiber optic transceiver device installed in the Controller. Communications between local Controllers and the System Master shall be facilitated by the use of fiber optic modems. The modems shall be capable of communicating manufacturer specific data protocol and data information utilized by the traffic signal Controller in a coordinated Closed Loop traffic control system. Modems shall be active devices providing full duplex communications via an RS 232 input and support rebroadcast of data bi-directionally. Data received from the RS 232 port shall be verified as correct format and data valid prior to transmission. Data received from the fiber shall be decoded and verified as correct format and data valid prior to outputting to the RS 232 port. This confirmed data shall be rebroadcast via the transmit port to the next unit in the daisy chain installation. The modem shall be of a baud rate acceptable to the traffic Controller output and may broadcast at a rate from 1200 Hz to 28.8 kHz baud rate. The nominal wavelength of light transmission shall be 850 nm. A minimum of two ports shall be provided for fiber optic transmission plus the installation of the RS-232 port. Each fiber optic port shall be provided with an indicator as to transmitter or receiver function and each port shall be ST-PC style. The modem design and construction shall comply with all design standards,

especially environmental and physical, of NEMA TS-1 Standards of 1983. The modem shall be powered, unless otherwise specified internal to the Controller, from the Controller timing unit power supply.

Light Source.
A LED light source with a wavelength of nominal 850 nm shall be used, where the specified wavelength is 850nm. The LED shall be stable to within 0.1 dB in intensity over a period of sufficient duration to measure source. The output of the LED shall overfill the input end of the launch fiber in both numerical aperture <NA> and core diameter.

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. Unless otherwise approved by the Engineer, the fiber optic cable shall be as specified in the plans, Optical Cable Corporation BX series breakout riser cable, or approved equivalent.

Outdoor Self-supporting Cable.

Overhead fiber shall be Figure 8 configuration with the following minimum requirements:

Central Strength Member:	Dielectric Material (Epoxy/Fiberglass rod)
Outer Jacket:	Black high-density polyethylene
Messenger:	8.2M EHS, 1/4 inch galvanized steel
Messenger Breaking Strength:	8000 lbs.
Minimum bend radius:	8.1 inches
Operating/storage temperature:	+158ºF to -40ºF
Maximum Span Length:	500 feet

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.

After the complete System is installed and terminated, but excluding the capping of unused fibers, an OTDR reading shall be preformed 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. The complete documentation file of all tests conducted and factory tests shall be submitted to the Engineer.

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 handhold 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.

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 lbs. or the cable manufacture's recommendations, which ever 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, AWG No. 12 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.

K. GROUNDING SYSTEM. (See plan details for further information.)

The safety ground shall be electrically isolated from A.C. Neutral. The cabinet shall be electrically connected to safety ground. All connections to grounding rod conductors shall be cadweld type connections.

The main grounding system to 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 Cadweld connectors to #2/0 copper cable. Bolt type clamps shall not be used. A common #2/0 copper cable may be connected into the disconnect equipment with the four cables being spliced at the base of the pole.

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

A 5/8 inch by 10 foot copper clad ground rod shall be installed at each lighting standard and traffic signal pole. These rods shall be interconnected to each other and the service panel. Interconnection conductors shall be a minimum of #6 copper wire and have an insulation type of TW or approved equal. The rod shall be offset below grade to extend into earth and be centered in base in top end of concrete and extend approximately 6 inches above concrete.

All loop detector lead-in cables shall have the drain shield wire grounded at the point where the loop wires are connected to the lead-in cables. The drain shield wire shall be removed and covered at the cabinet. The loop lead-in grounding system shall not be connected to or come in contact with any portion of the remainder of the AC grounding system.

L. CONTRACTOR COORDINATION

The Contractor shall coordinate with the City of Council Bluffs Permits & Inspections Department and the local power company for the electrical connection for the 120 VAC power source to the Controller. Conduit and wire as specified in the plans shall be furnished and installed from the point of the power source to the cabinet. The cost of furnishing and installing this conduit and wire and the termination shall be considered incidental to the project and no additional bid item is provided other than the installation of the Controller. All conduit, wiring, and power service installations shall meet or exceed current National Electrical Codes and any other applicable local codes and ordinances.

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

M. 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 owner 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.

N. VEHICULAR SIGNAL HEADS

1. 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.

2. 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.

3. 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.

4. 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.

5. 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.

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

7. 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 5 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.

8. All vehicle signal indications (red, yellow and green) shall be the Dialight 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 signals shall meet ITE specifications for signal color and intensity.

O. PEDESTRIAN SIGNAL HEADS

1. The pedestrian head assemblies shall conform to the following. The pedestrian signal head shall comply with the latest version of the Institute of Transportation Engineers Standards on Pedestrian Traffic Control Signal Indications and the Manual on Uniform Traffic Control Devices. The pedestrian signal head shall be a stacked two-section head with 12 inch lenses or one 18 inch section with side-by-side indications as shown on the plans.

2. Signal Head Assembly

    a. The signal heads shall use the international symbols (walking person and raised hand).
    b. Lenses shall be polycarbonate; glass lenses are not acceptable.

c. All pedestrian signal indications shall be LED. The “walking person” symbol and “raised hand” symbol shall be Dialight LED display or approved equal. All LED signal indications shall meet ITE specifications for signal color and intensity.
d. The “raised hand” symbol shall be Portland orange and the “walking person” symbol shall be lunar white.
e. The color of all polycarbonate signal heads, except door fronts and inside and outside of visors, shall be federal yellow. Door fronts and inside and outside of visors shall be black in their entirety. The color shall be an integral part of the materials composition.
f. Pedestrian signal mounting hardware shall consist of 1 1/2 inch diameter polycarbonate with appropriate fittings and shall be federal yellow. Pedestrian signals shall be secured to pole by using a minimum 5/8 inch wide stainless steel band.
g. The pedestrian signal head shall include polycarbonate visors for each section. Visors shall be a minimum of 9 inches long.
h. The one-section pedestrian head shall include a 1 1/2 inch deep egg crate or Z-crate screen of polycarbonate.

P. MAST ARMS AND POLES

All standard sized poles and mast arms shall be fabricated from City of Council Bluffs pre-approved traffic signal pole design standards. Mast arm lengths will be selected by matching the required size to the nearest 5 foot interval available. All mast arms will be equal to or greater in length to the 5 foot intervals. In the event special sized poles and mast arms are required for a signalization project, the Contractor shall submit from the pole manufacturer calculations of all loads transmitted to the bases prior to fabrication. Calculations shall be stamped by a registered professional engineer in the State of Iowa. All calculations shall be submitted with shop drawings and shall be reviewed by the Engineer prior to fabrication.

Q. POLE BASES

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

   a. Electrical cable for intersection signalization shall be rated 600 volts minimum and be IMSA specification cable where applicable.
   b. The number of conductors and size of all electrical cable shall be as shown on the plans.
   c. 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, 105ºC, 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. Power Lead-In Cable

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

3. Signal Cable

   a. Signal cable shall be 600 volt, multi-conductor, with copper conductor of the number and size as shown on the plans.
   b. 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 #14 AWG unless otherwise specified on the plans.

4. Loop Detector Wire (With Plastic Tubing)

   a. The loop wire shall meet the requirements of the International Municipal Signal Association (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 #16 AWG unless otherwise specified on the plans.

5. Detector Lead-in Cable

   Detector lead-in cable shall meet the requirements of the international Municipal Signal Association (IMSA) specification 50-2, latest revision thereof for polyethylene insulated, polyethylene jacketed loop detector lead-in cable. All conductors shall be # 14 AWG unless otherwise specified on the plans.

6. Communications Cable (Telephone) (When Applicable)

a. Traffic control communications cable for signal interconnection circuits shall be #19 A.W.G., solid copper conductor, twisted pairs. The cable shall meet the requirements of the International Municipal Signal Association (IMSA) specification 39-2, latest revision thereof for paired polyethylene insulated, polyvinyl chloride jacketed cable with electrical shielding.
b. The number of twisted pairs required shall be as shown on the plans (minimum of two pairs).

7. Tracer Cable

a. A tracer cable shall be installed in all conduits with signal cables, detector lead-in cables, or fiber optic communication cables.
b. The tracer cable shall be a single conductor, stranded copper, AWG #12, Type THHN, with UL approval and an orange colored jacket.
c. The tracer cable shall be identified in the Controller cabinet, handholes, and poles by means of identification tags.

8. Grounding Cables

a. The ground cables from the service to ground rods shall be #2/0 stranded copper cable. Splices to connect multiple grounding cables shall be made with either copper split bolt connectors or pressure applied crimp connectors.
b. Grounding conductors within lighting standards and traffic signal poles shall be a #6 copper cable.
c. All grounding conductors which tie grounding systems together with conduits shall be a #6 copper cable with a TW insulating jacket.
d. All grounding conductors that connect bonding bushings to grounding systems shall be a #6 copper cable.
e. All grounding conductors between terminal strip support plates and the cabinet grounding bus shall be a minimum of a #10 copper cable or a braided copper cable with equal cross sectional area.

T. LOOP DETECTOR INSTALLATION

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.

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 5 turns per 1 foot, including lengths in conduits and service boxes.

3. Splicing. Refer to Articles U, V, and W below.

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.

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

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.

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.

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.

9. Multiple Loop Configurations. Multiple loop configurations, spliced to a single lead-in loop, to be connected in series shall have the connections made as per multiple loop details.

10. Preformed Loops. In all projects where new pavement is to be placed in the loop areas and wherever possible and practical, 6 foot by 6 foot diamond/square shaped preformed loops shall be installed within or under the pavement in lieu of pavement sawn loops. The Engineer shall be notified when the Contractor requests to substitute pavement sawn loops for preformed loops and the Engineer shall determine if the request should be approved. The preformed loops shall consist of one-half inch rigid polyvinyl chloride conduit with approved IMSA loop wire conductors placed within the conduit. The conductors within the conduit shall be held firmly in placed by a filler material such as backer rod, expanding foam, or silicone based sealants, which will remain flexible and provide rigidity to the conductors throughout the life of the preformed loop. The conduit shall be thoroughly solvent welded to prevent moisture infiltration and provide mechanical strength to the loop. A PVC pulling elbow shall be placed at the point where the lead-in point meets the edge of the loop.

11. Loop Testing. After installation of the loops, the Contractor should meter the loops by test instruments capable of measuring electrical values of installed loop wires and lead-ins to measure induced AC voltage, inductance in microhenries, high-low "Q" indication, leakage resistance in megohms, and the resistance of the conductors in ohms. The Contractor shall also provide the Engineer with a report on company letterhead indicating the inductance and leakage to ground test values for each loop. The test shall be conducted from the curbside handhole. An inductance and leakage to ground 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. Before beginning the required test period, the Engineer may independently meter any or all loops. Should any loop be found

unacceptable, the Contractor may be required, at his own expense, to replace the loop installation. The Contractor shall test the detector loops in the presence of the owner. The Contractor shall test each loop lead-in, fully connected, with a loop frequency meter at the time of the tests. Loop frequencies shall be within traditional ranges for similar loop configurations and comparable lead-in cable lengths.

12. Loop Testing Personnel. The above loop testing shall be performed by a person knowledgeable in the operation of the test devices and loop detector applications. The Contractor shall submit forty-five days prior to testing the name of the individual responsible for the testing, the agency and the procedure for the tests to be conducted. The procedure shall include the test to be performed plus all equational analysis reflecting anticipated results. The owner shall review the submitted procedures and qualifications of the individual to perform the test. The owner has sole right to accept or reject individuals or agencies based on data submitted or at the time of testing. (See test sample sheet.)

13. Typical Loop Testing Results

An acceptable loop installation shall be defined as follows:

Induced voltage test:

No deflection on the pointer of a volt meter.

Inductance:

The inductance reading on the loop tester is approximately the calculated value.

Loop Q:

Deflection of the pointer to the upper side of the scale.

Leakage to Ground:

Deflection of the pointer to above 5 megohms.

Loop Resistance:

The resistance reading on an ohm meter is approximately the calculated value.

Any unusual reading on the above shall be reported to the Engineer before sealing the loop in the pavement.

An unacceptable loop installation shall be defined as follows:

Inductance:

The inductance reading is below the calculated value.

Leakage to Ground:

Deflection of the point to below 5 megohms.

Loop Resistance:

The resistance reading is 50% more than calculated.

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.

14. Loop Detector Saw Slot Filler

    a. 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 percent or less without excessive flow of material, unless otherwise approved by the Engineer.
    b. 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.
    c. 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.
    d. 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.

U. WIRE SPLICING

1. 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.

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

3. 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.

4. 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.

5. 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.

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

7. 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.

V. SERIES LOOP SENSOR WIRES

1. 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.

2. 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.

3. 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.

W. LOOP LEAD-IN WIRES

1. The wires shall be soldered together leaving only enough exposed insulation and conductor to make the splice.

2. The drain wire shall be inserted into and then back out of the 3M-3832 sealant can and then connected to the ground rod in the handhole.

3. A layer of heat shrink tube shall be installed over the conductor cables.

4. Insert the lead-in cable and loop wires into the 3M-3832 series sealant can. The cables shall be fastened securely into the plastic cap retainer.

5. Install sealant can on the 3832 unit.

6. Two strain relief nylon straps shall be installed approximately 2 inches from the 3-M sealant unit and 1/2 inch intervals.

X. STREET NAME AND REGULATORY SIGNS MOUNTED ON SIGNALS

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.

Y. STREET LIGHTS

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

Z. REMOVAL OF EXISTING EQUIPMENT

The Contractor shall coordinate the removal of any existing equipment to include stop signs and poles with the City Traffic Maintenance Department in order that the City can coordinate the on-lining of the signals and timely removal of the signs required.

AA. 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.

BB. 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.