SECTION 92

TRAFFIC SIGNALS AND ROADWAY LIGHTING

92.1 DESCRIPTION

A. General

This work consists of furnishing and installing roadway lighting and traffic signals and components. All existing roadway lighting and traffic signal components not reused shall remain the property of the City and shall be salvaged to the City of Rapid City Steele Avenue yard in good condition.

B. Related Work

Section 90 Traffic Control
Section 91 Traffic Control Devices
Section 93 Pavement Marking and Permanent Signage

92.2 MATERIALS

A. Electrical Grounding and Bonding

1. Grounding wire from electrical cabinets to the ground rod shall be bare, soft drawn copper, sized per NEC. Grounding wire from pole to ground rod shall be bare, soft drawn copper, minimum size No. 6 AWG.

2. Bonding conductors shall be of the same size and insulation grade as the associated circuit conductors. Load size bonding jumpers shall not be smaller than the applicable size listed by the NEC, Table 250-95.

3. Ground rods shall be copper-coated electrodes in accordance with UL. The size and length shall conform to NEC requirements.

B. Electrical Conduit

1. Rigid steel conduit and fittings shall meet the requirements of UL 6 and 514 and shall be hot-dip galvanized. Each section of conduit shall bear the UL label.

2. Rigid non-metallic conduit and fittings shall be polyvinyl chloride heavy wall meeting the requirements of UL 651 and 514. Use and installation of PVC Schedule 40 and 80 shall be in accordance with NEC Article 347, and each section shall bear the UL label. If non-metallic conduit is to be used in areas subject to vehicular traffic, it shall be Schedule 80.

3. Intermediate metal conduit and fittings shall conform to the requirements of the UL, and each section of conduit shall bear the UL label. Intermediate conduit shall be galvanized on the outside surface.

C. Junction Boxes

1. Junction boxes shall be of a non-metallic material and conform to National Electrical Code standards 314.29 and 314.30~~Corrugated metal pipe shall conform to the requirements of AASHTO M 36~~. The word "ELECTRIC(AL)" shall be cast into the top of the cover.

2. Surface-mounted boxes shall be a non-corrosive metal box with a NEMA rain-tight lid designed for mounting on any surface to which a conduit can be attached. The box shall be a manufactured electrical box suitable for accepting conduit junctions, electrical wire splices and for use as a pulling facility for electrical wire.

~~3.Lid and cover assemblies for corrugated metal junction boxes shall be cast-iron Neenah Foundry Co. R5900-3 Series or equal. The word "ELECTRIC(AL)" shall be cast into the top of the cover. All covers shall be bonded prior to wire activation.~~

D. Concrete Footings

Concrete for footings shall meet the requirements for Class M6 concrete. Cement shall be Type II. Vertical reinforcement shall be Grade 60 and shall conform to the requirements of ASTM A 615. Circular ties, stirrups and spiral reinforcing may be fabricated from cold drawn wire ASTM A 82 or hot rolled plain or deformed bars conforming to the strength requirements of ASTM A 615 grade 60. Anchor bolts shall conform to requirements specified in Section 92.2 E.

E. Anchor Bolts

Anchor bolts for lighting poles and mast arm signal poles shall be per pole manufacturer's design. Only rolled threads may be used. The nuts, washers, and at least 3 in. plus the threaded length of the threaded end shall be galvanized in accordance with ASTM A 153.

Anchor bolts for pedestal signal poles and cabinets shall be per the manufacturer's design.

F. Electrical Power Cable

1. Electrical cables shall be rated for 600 VAC and be clearly and durably marked with the UL label, type of insulation, number of conductors and AWG size.

2. Traffic signals and traffic signals with intersection lighting using the same service cabinet shall utilize stranded copper meeting the requirements of ASTM B3 and B8, Class C.

3. Roadway lighting shall utilize stranded conductors of aluminum or copper for service, feeder and branch circuits.

4. All underground wire shall be installed in conduit.

5. All wire #2 AWG or smaller shall be factory colored as follows to reflect the application:

   White for grounded conductor;
   Green for grounding conductor; and
   Red and black for ungrounded conductors.

6. Pole and Bracket Cable

   The cable from pole base to luminaire shall be two-conductor of the AWG size shown, meeting ICEA standards.

   Conductors shall be stranded bare soft copper meeting ASTM B3 and B8, Class C. Each conductor shall be insulated with high dielectric strength heat and moisture-resistant polyvinyl chloride rated for use at 75 degrees C and shall meet the requirements of ICEA S-61-402 Section 7.1.3 and subsequent revisions. One insulated conductor shall be colored white and the other black. The two insulated conductors shall be laid parallel and covered with a black polyethylene belt. The belt shall meet the requirements of ICEA S-61-402 Section 7.1.5 and subsequent revisions.

G. Electrical Service Cabinet

The electrical service cabinet shall:

- Meet NEMA standard for rain-tight;
- Be equipped with a lock and two keys;
- Sized as required to house required components; and
- Be rated for service entrance equipment.

The following components are required:

- Main breaker
- A copper bus rated for the voltage, current, and phases required by the plans
- Branch circuit breakers meeting plan requirements for amps, voltage, and phases. Minimum A.I.C. shall be 10,000
- When fused disconnects are required, the disconnects shall be rated for the voltage and current shown on the plans and shall be UL rated.
- When plans require, a mechanically-held contactor, NEMA-rated for the load served, shall be provided. The contactor shall be encased in a UL approved weatherproof housing with an integral test switch included. The contactor shall

be complete with an interface relay for photocell control and photocell by-pass switch. A photocell shall be provided.

H. Luminaires

1. Must be a complete lighting device, weatherproof, with cast aluminum housing, reflector, refractor, lamp, lamp socket, terminal block, integral ballast and with internal parts readily accessible.

2. Mounting must be by a 2 in. slip fitter (except for wall mounts).

3. Refractor shall be constructed of clear, heat- and shock-resistant glass or material, which gives similar light transmission with superior shock resistance.

4. Ballast shall be constant-wattage and multiple-voltage.

5. Wall mount luminaires must be vandal-resistant.

I. Photoelectric Control Requirements

1. The photoelectric cell shall meet EEI/NEMA and ANSI C136-10 standards and subsequent revisions, and shall have an outside diameter of three in.

2. The housing shall be non-metallic and weatherproof and the cover must be ultraviolet light stabilized and impact-resistant.

3. The load switch must be an electromagnetic relay.

4. Mounting shall be to an EEI/NEMA three-terminal, polarized, twist-lock-type receptacle.

5. Shall operate on any electrical power between 105 and 285 volts, 50 to 60 hertz alternating current.

6. Shall be equipped with an expulsion-type arrester for surge protection.

7. Shall have a minimum of three seconds time delay to eliminate false operation due to lightning or stray passing lights.

8. Shall provide for fail-safe operation. The light shall remain "ON" if the control fails.

9. Factory set to turn on at 1.0 foot-candles and off at 3.0 foot-candles.

J. Roadway Lighting Poles

1. Design and Fabrication

a. Design and fabrication shall be in accordance with "AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals" and plan details. Design shall also include provision for the mounting of a 30 in. x 36 in. sign located 10 fee0t above the base.

b. The design wind velocity shall be 80 mph and the gust factor 1.3.

c. The design yield strength for steel shall be no higher than 55,000 psi. Yield strength of the steel used in fabricating poles may be higher than 55,000 psi but shall not be lower than 36,000 psi.

d. Transformer base poles shall be provided and all poles on a contract must be of the same type.

e. Anchor bolt circle, anchor bolt size and other structural properties of the pole and base are to be designed and determined by the pole manufacturer.

f. Pole designs must provide for drainage with no laps or edges to hold moisture.

g. Mast arm pole shafts shall have a removable cover and an opening for cable entrance to the mast arm.

h. A cable strain relief connector shall be provided at the point of entrance to the mast arm or electrical fixture.

i. Hand holes and other openings shall be smooth and neat. A 1/2 inch nut shall be welded inside the hand hole for grounding purposes. The weld shall not show through to the outside.

j. A junction box shall be provided within two feet of the base of the pole with conduit running from the J-box into the pole housing.

2. A statement is required, signed by a Registered Professional Engineer, certifying that the pole designs meet all plan and specification requirements.

3. Three copies of shop drawings, design calculations and certifications for poles shall be furnished. The Engineer shall retain one copy, submit one copy to the Traffic Engineer for review and submit the third copy to the maintaining authority.

K. Traffic Signal Poles

1. Design and Fabrication

a. The location, number, area and weight of the signal heads as shown on the plan detail plates shall be used for determination of adequate mast arm, pole and footing structural design. The actual quantity and locations of signal heads shall be as shown on the plan sheet.

b. The design shall also include provisions for:

One mast arm mounted street name sign (18 inches x 72 inches minimum); One additional mast arm mounted sign (30 inches x 36 inches) for each 10 feet of mast arm length; One pole mounted sign (30 inches x 36 inches) located 10 feet above the base; and Preemption and video detection equipment.

c. Design and fabrication shall be in accordance with "AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals" and plan details.

d. The design wind velocity shall be 80 mph and the gust factor 1.3.

e. The design yield strength shall be no higher than 55,000 psi. Strength of steel for fabricating poles may be higher than 55,000 psi but not lower than 36,000 psi.

f. Transformer base poles shall be provided and all poles on a contract must be of the same type.

g. Anchor bolt circle, anchor bolt size and other structural properties of the pole and base are to be designed and determined by the pole manufacturer.

~~h. A terminal block with enough connections to accommodate all conductors, including spares, as shown on the field wiring diagram, is to be provided in the base of the pole.~~

i. Pole designs must provide for drainage with no laps or edges to hold moisture.

j. Mast arm pole shafts shall have a removable cover and an opening for cable entrance to the mast arm.

k. Luminaire extensions shall meet specifications for Roadway Lighting Poles.

l. Hand holes and other openings shall be smooth and neat. A 1/2 inch nut shall be welded inside the hand hole for grounding purposes. The weld shall not show through to the outside.

m. All poles shall be designed with rotateable arms.

n. A cable strain relief connector shall be provided at the point of entrance to the mast arm or electrical fixture.

o. The end of all mast arms shall be internally accessible through a hand hole.

2. A statement is required, signed by a Registered Professional Engineer, certifying that the pole designs meet all plan and specification requirements.

3. Three copies of shop drawings, design calculations and certifications shall be furnished. The Engineer shall retain one copy, submit one copy to the Traffic Engineer for review and submit the third copy to the maintaining authority.

L. Traffic Signal Control Cable

1. Multiple Conductor Cable shall be THHN/THWN insulated conductors with fillers of non-absorbent material, bound with polyester tape and with a polyvinyl chloride jacket. Two-conductor cables may be either round or flat construction.

2. Conductors shall be Class C stranded copper meeting the requirements of ASTM B3 and B8.

3. Insulation shall have a minimum thickness of 19 mils, of which 15 mils shall be polyvinyl chloride with the remaining thickness of nylon.

4. Conductor insulation shall be colored in accordance with ICEA S-61-402, Method 1, Table K-2.

5. Jackets shall be polyvinyl chloride meeting UL requirements for Class 12 jackets and ICEA S-61-402 Section 4.3.1, thickness per Table 4.5

6. The cable shall be marked with the manufacturer's name, rated voltage, UL label, AWG size and number of conductors.

M. Traffic Signal Controller & Cabinet Assembly

All traffic signal controller units shall be equipped with a communication module and operating software that is fully compatible with the master controllers and central software systems currently owned and utilized by the City in the operation of its signal network.

1. NEMA TS1 Type 1

a. Controller

1. The controller shall be a solid state, digital, NEMA TS1 Type 1.

2. Controllers shall be two through twelve phase controllers.

3. The controller unit shall provide preemption capable of containing up to six distinct sequences, including low priority sequences.

4. Vehicle detectors shall operate in the presence (non-locking) mode and shall have call delay timing capability. This call feature shall be inhibited by the controller.

5. Digital timing shall be provided with battery backup.

6. The controller may alternate the red and yellow indications when flashing or flash all-red.

7. The controllers shall be capable of programming by manual entry via the front panel keyboard, data down loading via null-modem cable, and data down loading from controller to another via serial port connection.

8. The controller shall be capable of operating coordinated by time-based, hardwire and telemetry.

9. The controller shall have a copy function to copy all timing data from one phase to another. The controller shall also permit copying all coordination pattern data from one pattern to another.

10. The controller shall have internal signal dimming.

11. The controller solid state flasher shall have dimming capability.

12. The City is responsible for programming controllers with the signal timings shown on plan sheets.

13. The controller shall be equipped with a police push button with appropriate length of cable.

14. The controller or the conflict monitor shall record significant events and then generate a report from data logged. Monitor status bits shall be on the back panel. Reports shall be transmitted to an external printer or portable computer using the RS232 port on the front of either unit. Data records shall be time and date stamped and shall include, as a minimum, the following types of records:

    - Power on/off, interruption

- Power on self-test diagnostics pass/fail
- Conflict Monitor Status (Conflict, Red Fail, etc.)
- On/off status of 8 user defined inputs
- Remote Flash on/off
- Manual control Enable on/off
- Start and end of each pre-empt sequence
- Cycle failure
- Enter/exit system operation
- Flasher failure (2 AC inputs)
- Detector 1-24 out of threshold
- Detector 1-24 no activity
- Detector 1-24 constant call
- Detector 1-24 Return to normal
- Phase 1-8 in/out of Detector Max Fail Recall mode

b. Cabinets

1. General

1) Controller cabinets shall meet the requirements of NEMA TS1.

2) The controller cabinet shall be made of sheet aluminum alloy and be mounted as shown in the plans. It shall be a Type P cabinet with minimum dimensions of 55 in. H x 44 in. W x 26 in. D. It shall have the following features and accessory equipment:

i. Unpainted natural aluminum finish.

ii. Gasketed main door (right side hinged) with standard lock and two keys and doorstop.

iii. Gasketed police panel door with police lock, 2 keys, flash switch and signal shutdown switch. At any switch position, power shall be maintained on all control equipment, including detector amplifier units, within the cabinet. The switch shall be labeled and rated for the current load. Switch terminals on the rear of the police panel shall be insulated so live parts are not exposed.

iv. Thermostatically controlled fan installed in plenum in roof of cabinet. Turn-on temperature

adjustable between 70° and 160°F and shall be separately fused.

v. Filtered air intake of at least 12 square inches near the bottom of the cabinet, designed to prevent the entrance of dust, insects and blowing rain and snow. Filter removable for cleaning or replacement.

vi. Solid state dimmable flasher conforming to NEMA Standard TSI Part 8, Type 3. Heavy duty flash transfer relays shall be provided.

vii. Solid state load switches conforming to NEMA Standard TSI Part 5 shall be provided in sufficient numbers to provide the sequence shown in the plans.

viii. Dual ring, 12-position back panel.

ix. Maintenance switches inside the cabinet shall include the following:

a) Stop Time Control

b) Timer Power

c) Flash

d) Vehicle detector input for each phase in use

e) Pedestrian input for each phase in use

x. Loop detector amplifiers and harnesses shall be furnished in sufficient quantity to accommodate the detector loops as shown in the plans. They shall be 4-channel units with LCD displays, Model U-1200 as manufactured by Reno A&E.

xi. A 12-channel conflict monitor shall be provided. It shall conform to NEMA TSI-1989 and be equipped with an LCD display, keyboard and event logging features.

xii. Anchor bolts (set of 4).

3) A 6 inch square vinyl decal shall be provided on the cabinet door showing the intersection layout, signal phasing with phase numbers and detectors.

2. Electrical

1) Duplex receptacle with ground fault interrupter, lamp base with toggle switch. Outlet and lamp to be fused ahead of the main circuit breaker. A non-GFI receptacle shall also be provided and mounted near the controller shelf.

2) A main circuit breaker shall be furnished and installed in the controller cabinet. An auxiliary circuit breaker shall be provided and connected to the load size of the main breaker. The main breaker shall be wired to protect the signal load and controller circuits. The auxiliary circuit breaker shall be properly rated and fused to protect circuits utilizing unfiltered AC power.

3) Terminal facilities in the cabinet for incoming AC power will be protected to prevent short-circuiting when working with tools in the cabinet. The circuit breakers shall be capable of manual operation with markings to indicate ratings and whether it is in the open or closed position.

4) A power line filter meeting the following specifications shall be installed at the main breaker:

- 50db minimum attenuation over a frequency range of 200 kilohertz to 75 kilohertz.
- Hermetically sealed in a metal case.
- Minimum feed-through current of 30 amperes at 120 volts, 60 hertz.
- A minimum of a ¼ in. current path between input-output terminals and the metal case.
- Power input and output connections are made to 10-24 brass studs.
- An insulation factor between the line circuit and the metal case (ground) of 100M to 200M ohms.

5) Surge protection for dissipating line transient voltages shall be furnished and installed using a metal oxide vaistor rated at 20 joules with a 150-volt r.m.s. clipping voltage connected between each

120 VAC input line and AC common at the main breaker.

6) The 120 VAC power feed at the entrance to the controller cabinet shall be protected against lightning by a rare gas arrester. The arrester shall be located in advance of both the surge protector and the main circuit breaker, be properly grounded and conform to the following:

- Replaceable, self-restoring, rare gas cartridge with hermetically-sealed metal electrodes;
- Induction discharge period in excess of 5 amperes r.m.s. for 2 minutes or 25 amperes r.m.s. for one second or 15 amperes r.m.s. for 10 seconds, all followed by complete restoration to original characteristics.
- Discharge voltage minimum of 200 volts.
- Mounted on a standard AAR porcelain base equipped with a spark gap discharge feature.

7) Bus bar terminals such as AC common (neutral), AC power, safety (chassis) ground and AC signal power shall be furnished and properly installed.

8) Terminals and panel wiring for detector leads, interconnect, time switches, relays, load switch sockets, flash transfer relay sockets and any other components required to provide the controller operation shall be installed.

9) Terminals and components that make up the basic terminal facilities shall be permanently identified in accordance with the cabinet wiring diagram. Identification shall be permanently attached as close as possible to the terminal or component and shall not be affixed to any part that can easily be removed.

10) Each input or output terminated on a terminal block, shall be identified on the front of the panel by a position number and functional terminology (e.g. 0/1 Red, 0/2 Hold, Channel 3 Red, etc.). The same identification shall be used consistently on the cabinet wiring diagram.

11) Each component shall be identified on the front of the panel by a symbol and function terminology

consistent with the cabinet wiring diagram. Provisions shall be made that each load switch socket may be identified by the phase or overlap number by writing on the panel in an area established for this feature.

12) Panel wiring shall be neat and firm with panel-mounted terminals for signal lamp circuit conductors, one for each signal circuit and one or more terminals for the common conductor. The terminals shall be located a minimum of three inches from the bottom of the cabinet and arranged for adequate clearance between the terminals. The controller equipment and terminals shall be arranged within the cabinet so they will not upset the entrance, training and connection of incoming conductors.

13) Interface panels shall receive twelve (12) load switches.

14) Controller cabinets shall be equipped with a detector test push button panel to place vehicle and pedestrian calls into the controller. Push buttons shall provide for eight (8) vehicle phases and four (4) pedestrian phases. The push buttons for vehicle phases shall be capable of extending the associated phase by intermittent or continuous contact.

2. NEMA TS2 Type 1

a. Controller

1. The controller shall be a solid state, digital, NEMA TS2 Type 1.

2. Controllers shall be two through twelve phase controllers.

3. Vehicle detectors shall operate in the presence (non-locking) mode and shall have call delay timing capability. This call feature shall be inhibited by the controller. Vehicle detectors shall be set to a three (3) second delay.

4. Digital timing shall be provided with battery backup.

5. The controller may alternate the red and yellow indications when flashing or flash all-red.

6. The controllers shall be capable of programming by manual entry via the front panel keyboard, data down loading via null-modem cable, and data down loading from controller to another via serial port connection.

7. The controller shall be capable of operating coordinated by time-based, hardwire and telemetry.

8. The controller shall have a copy function to copy all timing data from one phase to another. The controller shall also permit copying all coordination pattern data from one pattern to another.

9. A malfunction management unit (MMU) shall be installed in each cabinet and shall conform to NEMA Standard TS2, Section 4.

10. The controller shall have internal signal dimming.

11. The controller solid state flasher shall have dimming capability.

12. The City is responsible for programming controllers with the signal timings shown on plan sheets.

13. Controllers shall be equipped with a police push button with appropriate length of cable.

b. Cabinets

1. General

1) Controller cabinets shall meet the requirements of NEMA Standard TS2.

2) A 6 inch square vinyl decal shall be provided on the cabinet door showing the intersection layout, signal phasing with phase numbers and detectors.

3) A sufficient quanatity of BUS interface units (BIU) shall be installed in the cabinet to provide communication between detectors, load switches, controller unit, etc. Each BIU shall conform to NEMA Standard TS2, Section 8.

4) The cabinet shall be constructed from type 5052-H32 aluminum with a minimum thickness of 0.125 inches. 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, blowholes and other irregularities. All sharp edges shall be ground smooth.

5) The eight phase cabinet shall consist of a size 6 cabinet.

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

7) The front edge of the shelves shall have holes punched every 6 inches to accommodate tie wrapping of cables/harnesses.

8) 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.

9) All 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.

10) All load switch and flash transfer relay socket reference designators shall be silk-screen labeled on the front and rear of the main panel to match drawing designations. Socket pins shall be marked for reference on the rear.

11) Field terminal blocks shall be wired to use four positions per vehicle or overlap phase (green, yellow, red, flash). It shall not be necessary to de-bus field terminal blocks for flash programming.

12) All main panel wiring shall conform to the following wire size and color:
   i. Green/Walk load switch output, brown wire, 14 gauge
   ii. Yellow load switch output, yellow wire, 14 gauge
   iii. Red/Don't Walk load switch output, red wire, 14 gauge
   iv. MMU (other than AC power), violet wire, 22 gauge
   v. Controller I/O, blue wire, 22 gauge

vi. AC Line (power panel to main panel), black wire, (1 for each 4 LS), 10 gauge
vii. AC Line (main panel), black wire, 14 gauge
viii. AC Neutral (power panel to main panel), white wire, 10 gauge
ix. Flash programming, flasher socket to terminal, orange wire, 14 gauge – flasher socket to red or yellow field terminal, black wire, 14 gauge
x. Earth ground (power panel), green wire, 8 gauge
xi. Logic ground, grey wire, 22 gauge

13) The main panel shall incorporate a relay to remove +24 VDC from the common side of the load switches when the intersection is placed into flash. The relay shall have a momentary pushbutton to apply power to the load switch inputs for ease of troubleshooting.

14) All test switch panel wiring shall be connected to the main panel via a multiple pin type connector.

15) The power bus assembly shall be manufactured from 0.009", 5052-H32 aluminum. It shall provide filtered power for the controller, MMU, cabinet power supply, and all auxiliary equipment. It shall include the SDLC bus connecting cables wired into a surface mounted compression terminal block. It shall have six power connectors.

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

17) Any defects shall be corrected by the manufacturer or supplier at no cost to the City.

~~This specification describes minimum acceptable design and operating requirements for a solid state two through eight phase controller unit, utilizing a menu driven keyboard and display format for all data entry and read-out. The controller unit shall contain, as a minimum, vehicle, pedestrian and volume density timing on all phases. The controller unit shall also contain time based coordination as a standard feature. These functions shall be accomplished using a 16 bit microprocessor to implement the timing control logic. The controller shall be a model LMD9211 meeting the requirements of NEMA Standard TSI-1989 parts 13 and 14.~~

1. General Design Requirements

a. The controller unit shall consist of a chassis suitable for shelf mounting, including processor module, power supply module, input/output module, display module, keyboard module, and auxiliary input/output module. Space shall be provided for an optional communications module for use in a closed loop environment or for direct dial telephone operation.

b. Operator programming and data retrieval shall be by means of a menu driven display and a keyboard located on the front panel of the unit. The display shall be a liquid crystal display (LCD) and contain a minimum of four lines with 40 characters per line. The display shall have a 16 range adjustment of contrast control and be back lighted. The keyboard shall be a domed, tactile feedback, membrane style keyboard. The display and keyboard shall be functional over the NEMA temperature range of –34°F to +165°F.

c. The keyboard shall include keys, which facilitate operation of a menu driven program. It shall include dedicated cursor arrow keys, page up, page down, main menu, prior menu, display contrast, run status, backlight control, clear, enter, help, as well as the digits 0-9 and a decimal point. Generic hexadecimal keypads will not be accepted. Context-sensitive help screens shall be provided which give a description of the functions on each screen.

d. Program data shall be retained in EEPROM and mounted on a removable program card. This card shall be suitable for transporting all programming data from one unit to another, including the current real time and date. The program card shall not exceed 9 square inches and shall include a battery to maintain current time and date while power is removed.

e. Non-program data such as volume log or measures of effectiveness (MOE) data may be stored in either battery backed RAM or EEPROM. Whichever method is chosen, a minimum of 128K of such memory shall be provided.

f. Two RS232C connectors shall be provided to allow for controller-to-controller transfer of data, printing of data and for uploading and downloading data to a computer either directly or via a dial-up telephone modem.

g. An auxiliary module shall be provided to accommodate direct 115 VAC interconnect-based coordination without secondary external interface, preemption and applications requiring additional inputs and outputs. An additional CPC connector (MSD) shall be provided to interconnect all inputs and outputs associated with the aforementioned functions. The MSD connector shall be fully compatible with other controller cabinets in the City of Rapid City.

h. The chassis shall be constructed so that adequate ventilation is achieved without any open holes in the top of the chassis. The chassis and circuit boards shall be designed to allow for normal handling of such components

without sustaining damage due to electro-static discharges. Any disclaimers printed on the chassis or any circuit boards suggesting that special handling is required or suggesting that the warranty may be voided if subjected to such electro-static discharges will be considered as evidence of defective design and will be considered as grounds for rejection of the controller.

2. Functional Operation

In addition to those timing intervals and functions defined in NEMA TSI-1989, the following features shall be provided:

a. A dimming input to the controller shall be provided that, when active, shall cause designated circuits to be pulsed on and off in conjunction with the AC power source. The result of the corresponding load switch output will be such that the effective voltage to the signal bulbs will be approximately 70 percent of the line voltage. The selection and mode of pulsing (positive or negative half wave) for each circuit shall be programmed to balance the electrical loads in keeping with good engineering practice.

b. Automatic Min Gap Recall shall be operator selectable. It shall be possible to not automatically place a call on a phase if the phase reaches its minimum gap. If enabled, the call would be placed after gap out termination of the phase.

c. Soft recall shall provide a recall for the phase(s) programmed, providing no other serviceable calls are present.

d. Simultaneous Gap Out shall be operator selectable. If Simultaneous Gap Out is enabled (standard NEMA), a phase will restart its passage timer upon demand regardless of any previous green rest condition. If Simultaneous Gap Out is inhibited, a phase will not restart its passage timer once it has rested waiting to cross the barrier under dual ring operation.

e. The overlap phases of an overlap shall be programmable through the keyboard. It shall be possible to modify the normal operation of the overlap to inhibit green or yellow indications during specific phase colors, such as for right turn overlaps when on during the through green. It shall also be possible to lag the clearance of overlaps A-D from their parent phase by a programmable amount, using their own yellow and red timing. The load switch drivers of any unused phase shall be programmable as overlap outputs.

f. The phases, which will be serviced prior to entering MUTCD (planned) flash and the phases serviced immediately following MUTCD flash shall be programmable.

g. Dynamic control of maximum green time shall be provided on a cycle-by-cycle basis. If a phase reaches the programmed maximum two consecutive

cycles, the maximum time is extended by a programmable increment up to a settable upper limit. If the phase then gaps out two consecutive cycles, the maximum time is decreased by the increment amount down to the programmed maximum time.

h. The ability to change minimum green, passage time, walk, pedestrian clearance, maximum green, recall and phase status shall be provided. Up to eight separate schedules shall be programmable and selected by the time of day or coordination program.

i. The unit shall provide a minimum of 24 vehicle detectors consisting of the 8 standard NEMA detectors plus 16 more through the auxiliary modules. Each detector shall provide programmable phase assignment, detector switching capability, plus stretch and delay timing operation.

j. The unit shall provide the capability of optionally monitoring each detector for acceptable operation based on its operation over a programmable sampling period and range. A detector not meeting acceptance criteria shall be considered failed. A failed detector can return to normal status at the end of the next sampling period if it returns to within range during that period.

3. Displays And Keyboard

a. The display shall operate in a true menu format whereby the display lists in English, various categories from which the user may select. The base menu shall contain, as a minimum, a mode to observe the controller timing and input/output status; a mode to read or program all settings; and a utilities mode for data management. The base menu shall list the most general category choices such as program mode and real time status. From this base menu, when a category is selected, a submenu appears listing further choices such as security code, controller, coordination, time clock, pre-emption, etc. Each submenu further breaks down the choices into more specific categories until the specific sections of data can be obtained. The display shall operate such that a user familiar with traffic terminology, but unfamiliar with the display can successfully operate the display by following menu selections.

b. The utilities menu shall allow the operator to perform as a minimum, the following functions:

- Loading backup timing for the controller, coordination, or time clock data;
- Clearing data to default settings for controller, coordination, or time clock data; and,
- Transfer data to another unit - personal computer or printer.

4.Time Clock

a. The internal time clock shall be a yearly programmable device consisting of programmed events, which are assigned to day programs (24 hours), such day programs being assigned to week programs (7 days), and such week programs being assigned to a year program. The real time clock shall operate on a 99-year calendar.

b. When enabled to do so, the time clock shall be able to control the coordination command set, thereby selecting the cycle, split, offset and system/free status in effect based on day program event selections.

c. Time clock internal function control. When enabled, it shall be possible to control functions by internal time clock without external wiring. As a minimum, it shall be possible to control the following functions by time of day:

- Coordination Cycle/Split/Offset
- MUTCD Flash
- Max II select
- Inhibit Max, per ring
- CNA I/II
- Min Recall, all phases
- Vehicle and Ped calls, per phase 1-8
- Vehicle and Ped omits, per phase 1-8
- Call Red Rest mode, per ring
- Omit all Red Clearance, per ring
- Enable Ped Recycle, per ring
- Detector monitor low threshold inhibit
- Detector monitor constant call inhibit
- Enable dual entry
- Conditional service enable
- Simultaneous gap out inhibit
- Disable interconnect (Enable time base coord)
- Inhibit volume density operation per phase
- Lag phases 1, 3, 5, 7
- Inhibit overlaps A, B, C, D
- Inhibit Detectors, 1-16
- Select Service Plan, 1-8
- Select Max Plan, 1-8
- Dimming

d. Sync reference modes. The coordination cycle in effect, when selected by time clock, shall be referenced to the time clock by means of a time base reference and not an input. The unit will automatically correct the cycle counter upon power-up as well as on command to the time base reference. To provide flexibility in adapting the unit to synchronize to other types of units,

at least four keyboard selectable methods consistent with industry standards of sync referencing shall be provided.

e. The unit shall contain 13 time clock outputs, which are assigned as follows:

Output #1	Cycle 2
Output #2	Cycle 3
Output #3	Offset 1
Output #5	Offset 2
Output #4	Offset 3
Output #6	Split 2
Output #7	Split 3
Output #8	Flash
Outputs #9-12	Auxiliary
Output #13	System

f. Clock Set. It shall be possible to manually set the time clock for the correct time to the correct hour, minute, second, year and date. Each output function shall be capable of being programmed in increments of one second.

g. Selection Modes. The unit shall provide a method of choosing the source for selection of the cycle, split, offset, flash and system commands. The sources provided shall be manually through the keyboard, time clock, AC interconnects, communications with time clock backup (closed loop system) or AC interconnect with time clock backup.

5. Coordination

a. The controller unit shall be capable of operating in a coordinated system and provide for the following coordination features:

- Eight cycles
- Four splits per cycle
- Five offsets per cycle
- Eight permissive periods per split
- Eight force-offs per split
- One pedestrian permissive, or automatic permissive
- One dwell period per cycle

b. Any controller unit shall be able to operate as a Master controller or as a secondary without requiring any changes in the unit itself.

c. The controller unit shall be capable of coordinated operation in response to internally generated time clock commands selecting cycle, split and offset. In this mode, the unit shall coordinate with other time base units in the City of Rapid City without need of interconnect. The time clock shall conform to requirements stipulated in Section 4 above, Time Clock.

d. The controller unit shall be equipped with a communication module and software that is fully compatible with the master controllers and central software currently owned and used by the City of Rapid City in the operation of their LM100 closed loop system.

6. The controller unit shall provide preemption capable of containing up to six distinct sequences, including low priority sequences.

7.Miscellaneous Features

The controller or the conflict monitor can record significant events and then generate a report from data logged. Monitor status bits shall be on the back panel. These reports can be transmitted to an external printer or portable computer using the RS232 port on the front of either unit. Data records shall be time and date stamped and shall include, as a minimum, the following types of records:

- Power on/off, interruption
- Power on self-test diagnostics pass/fail
- Conflict Monitor Status (Conflict, Red Fail, etc.)
- On/off status of 8 user defined inputs
- Remote Flash on/off
- Manual control Enable on/off
- Start and end of each pre-empt sequence
- Cycle failure
- Enter/exit system operation
- Flasher failure (2 AC inputs)
- Detector 1-24 out of threshold
- Detector 1-24 no activity
- Detector 1-24 constant call
- Detector 1-24 Return to normal
- Phase 1-8 in/out of Detector Max Fail Recall mode

8.The controller cabinet shall be made of sheet aluminum alloy and be mounted as shown in the plans. It shall be a Type P cabinet with minimum dimensions of 55 in. H x 44 in. W x 26 in. D. It shall have the following features and accessory equipment:

a. Unpainted natural aluminum finish.

b. Gasketed main door (right side hinged) with standard lock and two keys and doorstop.

c. Gasketed police panel door with police lock, 2 keys, flash switch and signal shutdown switch. At any switch position, power shall be maintained on all control equipment, including detector amplifier units, within the cabinet. The

switch shall be labeled and rated for the current load. Switch terminals on the rear of the police panel shall be insulated so live parts are not exposed.

d. Thermostatically controlled fan installed in plenum in roof of cabinet. Turn-on temperature adjustable between 70° and 160°F and shall be separately fused.

e. Filtered air intake of at least 12 square inches near the bottom of the cabinet, designed to prevent the entrance of dust, insects and blowing rain and snow. Filter removable for cleaning or replacement.

f. Solid state dimmable flasher conforming to NEMA Standard TSI Part 8, Type 3. Heavy duty flash transfer relays shall be provided.

g. Solid state load switches conforming to NEMA Standard TSI Part 5 shall be provided in sufficient numbers to provide the sequence shown in the plans.

h. Dual ring, 12-position back panel.

i. Maintenance switches inside the cabinet shall include the following:

- Stop Time Control
- Timer Power
- Flash
- Vehicle detector input for each phase in use
- Pedestrian input for each phase in use

j. Loop detector amplifiers and harnesses shall be furnished in sufficient quantity to accommodate the detector loops as shown in the plans. They shall be 4-channel units with LCD displays, Model U-1200 as manufactured by Reno A&E.

k. A 12-channel conflict monitor shall be provided. It shall conform to NEMA TSI-1989 and be equipped with an LCD display, keyboard and event logging features.

l.Anchor bolts (set of 4).

9. Electrical

a. Duplex receptacle with ground fault interrupter, lamp base with toggle switch. Outlet and lamp to be fused ahead of the main circuit breaker. A non-GFI receptacle shall also be provided and mounted near the controller shelf.

b. A main circuit breaker shall be furnished and installed in the controller cabinet. An auxiliary circuit breaker shall be provided and connected to the load size of the main breaker. The main breaker shall be wired to protect the

signal load and controller circuits. The auxiliary circuit breaker shall be properly rated and fused to protect circuits utilizing unfiltered AC power.

Terminal facilities in the cabinet for incoming AC power will be protected to prevent short-circuiting when working with tools in the cabinet. The circuit breakers shall be capable of manual operation with markings to indicate ratings and whether it is in the open or closed position.

c. A power line filter meeting the following specifications shall be installed at the main breaker:

- 50db minimum attenuation over a frequency range of 200 kilohertz to 75 kilohertz.
- Hermetically sealed in a metal case.
- Minimum feed-through current of 30 amperes at 120 volts, 60 hertz.
- A minimum of a ¼ in. current path between input-output terminals and the metal case.
- Power input and output connections are made to 10-24 brass studs.
- An insulation factor between the line circuit and the metal case (ground) of 100M to 200M ohms.

d. Surge protection for dissipating line transient voltages shall be furnished and installed using a metal oxide vaistor rated at 20 joules with a 150-volt r.m.s. clipping voltage connected between each 120 VAC input line and AC common at the main breaker.

e. The 120 VAC power feed at the entrance to the controller cabinet shall be protected against lightning by a rare gas arrester. The arrester shall be located in advance of both the surge protector and the main circuit breaker, be properly grounded and conform to the following:

- Replaceable, self-restoring, rare gas cartridge with hermetically-sealed metal electrodes;
- Induction discharge period in excess of 5 amperes r.m.s. for 2 minutes or 25 amperes r.m.s. for one second or 15 amperes r.m.s. for 10 seconds, all followed by complete restoration to original characteristics.
- Discharge voltage minimum of 200 volts.
- Mounted on a standard AAR porcelain base equipped with a spark gap discharge feature.

f. Bus bar terminals such as AC common (neutral), AC power, safety (chassis) ground and AC signal power shall be furnished and properly installed.

g. Terminals and panel wiring for detector leads, interconnect, time switches, relays, load switch sockets, flash transfer relay sockets and any other components required to provide the controller operation shall be installed.

~~h. Terminals and components that make up the basic terminal facilities shall be permanently identified in accordance with the cabinet wiring diagram. Identification shall be permanently attached as close as possible to the terminal or component and shall not be affixed to any part that can easily be removed.~~

~~i. Each input or output terminated on a terminal block, shall be identified on the front of the panel by a position number and functional terminology (e.g. 0/1 Red, 0/2 Hold, Channel 3 Red, etc.). The same identification shall be used consistently on the cabinet wiring diagram.~~

~~j. Each component shall be identified on the front of the panel by a symbol and function terminology consistent with the cabinet wiring diagram. Provisions shall be made that each load switch socket may be identified by the phase or overlap number by writing on the panel in an area established for this feature.~~

~~k. Panel wiring shall be neat and firm with panel-mounted terminals for signal lamp circuit conductors, one for each signal circuit and one or more terminals for the common conductor. The terminals shall be located a minimum of three inches from the bottom of the cabinet and arranged for adequate clearance between the terminals. The controller equipment and terminals shall be arranged within the cabinet so they will not upset the entrance, training and connection of incoming conductors.~~

N. Emergency Vehicle Preemption

1. System Description

a. This specification describes the minimum operating requirements of a siren activated emergency vehicle preemption system. The vehicle siren, which is standard equipment on all emergency vehicles, registers its presence by activation of the siren's "yelp, hi-lo, wail" modes. The system provides a method that allows an emergency vehicle to have priority over other vehicles and pedestrians at a traffic signal. All approaches to a signal serving vehicular traffic shall be equipped to provide priority to emergency vehicles. Under no circumstances shall any vehicular approach to a signal be unprotected. The system components are as follows:

1) Detectors - directional microphones at each approach to the signal that detect the imminent arrival of an emergency vehicle.

2) Phase selector - located in the signal controller cabinet. It processes the input detector information and produces an appropriate output to the signal controller.

3) Emitters - the existing electronic siren on each vehicle. Any electronic siren that meets current federal standards is compatible with the system. Sirens are not to be furnished as part of this project. The system shall be

expansible to include sirens that generate an embedded vehicle identification code that may be acquired in the future.

b. The signal controller shall be programmed for the special preemption sequence as shown in the plans. If shown on the plans, a confirmation light shall be installed on each approach that informs the driver whether the signal actually is under preemption control rather than normal operation.

2. Detector Devices

a. The detectors shall be specially designed microphones that are positioned on the traffic signal poles in such a manner that each approach to the signal is adequately detected. They shall be weatherproof and designed to withstand electrical transients normally encountered in the ambient outdoor environment. The detectors shall not be affected by fog, rain, ice, snow or other adverse weather conditions. The close proximity of high profile vehicles, e.g. large trucks, to an emergency vehicle shall not present a shield or barrier to the acoustical energy emitted from the siren. They shall be directional with an 18° cone of sensitivity and a polar curve of 9:1 (front to side). Electrical cable from the detector to controller cabinet shall be 18 AWG (minimum) 2-conductor, twisted, shielded pair such as Belden 8760 or equal.

b. Detectors shall be located as shown in the plans and shall be installed in strict accordance with the manufacturer's recommendations.

3. Phase Selector Device

a. The electronic device located in each signal controller cabinet is commonly referred to as a phase selector. This device is used to decode the information from each detector and produce suitable outputs to the controller. It shall be designed to meet the environmental and electrical standards specified by NEMA Standard TS1 or TS2. It shall be designed using microprocessor circuitry and shall be fully compatible with NEMA TS1 and NEMA TS2 controllers and cabinet assemblies.

b. Adjustment and calibration of the EVP system shall be a function of detector placement and phase selector inputs. The phase selector shall have resident software that allows range and sensitivity adjustments to be made using a portable computer.

c. The phase selector shall have adequate memory to record all system activity. Each access to the system shall be recorded with the date, time, duration of access, quality of the emitter/detector input signal, along with any other pertinent information. There shall be sufficient memory to store no less than 5,000 usage events. The event log shall be accessible by direct connection of the unit to a portable computer. (The portable computer shall not be furnished as part of this project.)

4. Technical Support Services

The manufacturer and/or supplier shall provide the initial setup and make adjustments that assure proper operation of the system. Technical training to the City shall be provided as necessary.

O. Video Detection System

~~1.Description~~

~~a.This specification describes the minimum design and operating requirements for a system utilizing closed circuit television cameras that produces reliable detection of all licensed vehicles including bicycles and motorcycles. The system also shall detect pedestrians.~~

~~b.The video detection system shall consist of up to 4 (8 with larger unit) data cameras, up to 1 (2 with larger unit) surveillance camera, a video processing unit and a coaxial cable network between the cameras and video processing unit.~~

~~2.~~1. Cameras

Cameras used in video detection systems shall be Autoscope Solo ® Pro or approved equal. Any “approved equal” shall be approved by the City and will be considered experimental for a 12-month period following installation. City acceptance of any “approved equal” will not occur until such units have been deemed to have operated successfully for the 12-month experimental period.

2. Equipment, Cables and Software

All associated video detection equipment and cabling shall be approved by the camera vendor or as accepted by the City.

System software shall be compatible with Autoscope Solo ® Pro software.

3. Warranty

The video detection system shall be warranted by its supplier for a minimum of two years. The warranty period for “approved equals” shall not commence until formal acceptance by the City.

~~a.Closed circuit television cameras (CCTV) provide the video signal for the system. The cameras shall be monochrome, high resolution (minimum of 580 lines of resolution) using either a 1/3 inch or ½ inch charge coupled device (CCD) and a zoom lens. The lens/CCD combination shall be as shown on the plans or as determined by the manufacturer. Lenses shall utilize auto-iris and auto-shutter features.~~

b.The camera shall be housed, as a minimum, in a NEMA-4 water-resistant, dustproof enclosure with a sunshield. The enclosure shall include a thermostatically controlled heater and a desiccant packet to control moisture and frost conditions.

c.The camera shall utilize a single MS-connector for interconnection to video and power cables.

d.The camera shall be mounted as shown in the plans using mounting adapters to minimize sway and motion.

3.Cables

a.The video cable between the controller cabinet and each camera shall be coaxial cable as defined below. The power cable shall be #14AWG (minimum) meeting the specifications for traffic signal cable. With the approval of the Engineer, the power cable may utilize spare conductors in the cables used for traffic signal circuits.

b.Underground coaxial cable

1)Any coaxial cable installed in underground conduits shall have a "maximum shield" outer conductor providing at least 96% shielding. The shield shall be copper braid of sufficient layers and weave to assure this degree of shielding. Aluminum foil or foil wrap shield is not acceptable.

2)The dielectric core material shall be solid polyethylene.

3)The outer jacket shall be a rugged non-contaminating, non-migratory polyethylene material.

4)The underground cable shall be Belden 8281.

c.Coaxial cable in poles (from base of pole to camera) shall be designed for practical flexibility:

1)The shield shall be braided copper providing at least 95% shielding. Aluminum foil or foil wrap is not acceptable.

2)The inner conductor shall be stranded copper.

3)The dielectric core material shall be foam polyethylene.

4)The outer jacket shall be PVC.

5)This cable, along with camera power cable shall be furnished by the camera manufacturer.

d.Coaxial connectors

1)Coaxial cables shall be terminated with Type BNC connectors using proper tools specifically intended for this purpose and good industry practice.

2)The underground coaxial cable connectors shall be Amphenol 31-71032 or approved equal.

3)The pole type coaxial cable connectors shall be Amphenol 31-71008 or approved equal.

4.Surge and Lightning Protection

a.A camera interface panel shall be provided in the controller cabinet for termination of the coaxial cables and camera power distribution. This panel shall provide lightning protection for both power and coaxial cables, terminal strips, ground buss, etc.

b.If provided by the manufacturer, a surge protector shall be installed on the pole near the camera mounting.

c.Except for locations with overhead power line or other clearance restrictions, poles used for camera locations shall have a detachable, 6 foot ground rod attached.

5.Video Processing Unit

a.Hardware Requirements

1)Chassis shall be suitable for either shelf or rack mounting in a standard 19 in. EIA rack. The unit is installed in the controller cabinet and shall be furnished with all cables and wire harnesses necessary for proper operation.

2)The unit shall be designed utilizing the industry standard VME (Versa Module Europe) bus system. Modules are inserted from the front of the chassis into connectors on the bus. All modules shall have slot ejectors.

3)The unit shall meet or exceed NEMA TS1 and TS2 environmental requirements. It shall operate over a temperature range from -40°C to +85°C, 0 to 95% non-condensing humidity.

4)The unit shall have Power On, Watchdog, and Sysfail indicators for easy visual verification of unit operation. The unit shall have (2) RS232 ports for serial communications up to 56.8K baud using 9-pin “D” sub-miniature connectors. The unit shall have a RS485 serial port that will interface to the NEMA TS2 Bus Interface Unit.

5)The unit shall accommodate up to 2 (4 with larger unit) input/output modules that provide interface to any standard NEMA or Type 170 signal controller. Each module will provide 32 inputs and 32 outputs that can be configured for either 12 volt or 24 volt operation.

a)The outputs correspond to detectors or user defined incidents that can be conditioned by special functions such as delay and extend timing. All outputs shall be monitored by internal diagnostics for proper operation. If an output or voltage level function should fall below required level of operation, the module will report the incident (Sysfail) to the CPU.

b)The inputs can correspond to the controller Phase Red or Green for detector functions, loop detector inputs for logging and comparison, or other inputs as necessary and available.

6)The unit will accommodate 1 or 2 Video Processing Modules. Each module shall provide (4) data video inputs, (1) surveillance video input and (1) video output. The video output is operator selectable from any of the five inputs. Indicator lights on the Video Processing Module shall indicate if the video supplied by the data inputs is present and useable.

b.Video Requirements

1)Video inputs can be either monochrome or color.

2)Any of the five video inputs (for each module) can be routed to the video output. Any of the five inputs can be sequence in any order or combination at any user programmed time slice, providing the user the capability of viewing all cameras on a system without requiring manual control or switching.

3)Digitized video can be transmitted via a serial port from any of the data cameras. Built-in compress/decompress (CODECS) software shall provide maximum frame rates for a given communications medium.

4)Real-time operation can be viewed either as digitized images on a computer at a given frame rate determined by the communication medium, or in full motion video on a video monitor connected to a computer providing the analog video is transmitted to the computer.

5)When furnished with a suitable modem, real time operation can be viewed using standard dial-up telephone lines connected to a computer.

c.Tracking and Detection

1)Accurate detection, removal of shadows, and tolerance to camera movement shall be accomplished using multi-resolution tracking

techniques. Detection of a vehicle or pedestrian takes place in user defined areas of interest called tracking strips. Each camera field of view (FOV) can support up to 5 tracking strips.

2)Tracking strips can be of any size and orientation within the FOV and are user defined as an irregular polygon with up to eight sides. Tracking strips are independent and can overlap and intersect. Vehicles shall be tracked across strips providing lane change reporting and logging on a lane to lane basis.

3)Up to 32 detection zones shall be available for each FOV (camera). A detection zone shall consist of a line of any length and orientation drawn on a video image. This line can consist of up to 4 points within or across any tracking strip. These lines can overlap and intersect as well as span multiple tracking strips. When a vehicle that is within a tracking strip converges on a detector line (zone), a detection output is generated. In addition to providing a detection output, each detection zone shall provide incident monitoring and data collection.

a)Detection zones shall be user assignable to any output, independent of logging and reporting functions. It shall be possible to assign multiple zones to the same output. When a detection zone is assigned to an output, it is defined as either a detection or incident output.

b)If the output is a detection output, it is further qualified to a mode of operation (presence, pulse, or stop bar) and conditions such as delay, extend, or switching can be applied.

c)If the output is an incident output, it shall be given a user defined output time for that particular incident that will control the status of the output. Incidents that can be monitored shall include wrong way detection, vehicle presence for “n” minutes, speed too fast/slow, queue length, red and yellow light running, etc. Incidents shall be user programmed for output, logging and automatic reporting back to a central location.

d)Each detection zone shall be capable of logging statistics on volume, occupancy, speed, density, headway, headway, and vehicle length in user defined time periods. This data shall be stored in FEPROM for zones selected by the user. The stored data shall be retrieved via the serial port upon demand by the user or in real time.

4)Each detection zone shall have built-in fault monitoring. Should an absence of vehicle presence exist for some user defined time period, the detection zone will be considered failed and that output will automatically resort to the default state defined by the user.

5)Detection accuracy for presence and volume shall exceed 99%.

P. Vehicle Detector Loops

1. Feeder wires from loop leads to detector units shall be RENO A & E LW-216 or approved equilvalent twisted shielded pair wires~~, #16 AWG minimum size~~. Splices are to be avoided in feeder wires where possible and are allowed only in junction boxes.

2. Unless otherwise specified on the plans, factory preformed loops shall be installed.

   a. Preformed loops shall be constructed using 9.5 mm (3/8 inch) I.D. polypropylene.

   b. Conduit shall be completely filled with a material specifically designed to withstand the heat of asphalt pavement construction, while retaining flexibility and protecting the encapsulated wires.

   ~~c.Encapsulated copper wire shall be 16 gauge TFFN stranded, single conductor with PVC insulation.~~

   ~~d.~~c. Wire lead-ins shall be twisted a minimum of 4 times per foot of length.

   ~~e.~~d. Lead-ins shall be attached to loop leads with Schedule 80 CVPC fittings.

   ~~f.~~e. All lead-ins shall be filled with a material specifically designed to withstand the heat of asphalt pavement construction, while retaining flexibility and protecting the encapsulated wires.

   ~~g.~~f. All wire runs shall be continuous through the loop and lead-ins.

   ~~h.~~g. All loops shall be tested at the factory prior to shipment. Testing documentation shall be provided to the Engineer prior to final acceptance.

3. Contractor Fabricated Preformed Loops

   When approved by the Engineer for applications in which the loops will not be in direct contact with hot asphalt, non-factory manufactured preformed loops may be acceptable. Non-factory manufactured preformed loops must meet the following criteria:

   a. Wire type shall be 14 ga. XHHW-2.

   b. Loop wire and lead-in wire shall be enclosed in ½ in. Sch. 40 PVC conduit. Fittings shall be Sch. 40 PVC, and all joints shall be waterproof.

   c. The tee, at the junction of lead-in conduit to loop conduit, shall be filled with a waterproof silicone sealant.

4. Sawed-In Loops

   a. Backer rod material shall be resilient, non-absorbent material approximately 25% larger in diameter than the width of the sawed slot to be sealed.

   b. The flexible embedding loop sealer shall be Preco Gold Label Flex, or approved equal.

   c. Wire type shall be RENO A & E LW 116-S or approved equivalent~~IMSA spec. 51-5~~.

   d. An extension from the loop to the pavement edge permitting wire routing to an adjacent pull box shall be considered as part of the work required for a sawed-in loop.

Q. Signal Heads

1. Vehicular and pedestrian signals shall be manufactured in polycarbonate sections. All sections shall be interchangeable and shall fit so they can be combined in a tier. Each section shall be of rugged, durable design using reinforcing ribs in both top and bottom as well as the interior of the housing.

   External reinforcing plates shall not be necessary for structural integrity and any requirement or recommendation by the manufacturer for the use of such plates shall be considered evidence of inferior design and cause for rejection. The mounting devices, lens indications, and other modifications shall be as shown in the project plans.

2. Pedestrian signals shall be constructed with both indications in a single housing. Pedestrian indications shall be 12 in. universal symbols.

3. Unless otherwise shown in the project plans, all signal indications shall be nominal 12 in. diameter. ~~Optical assemblies shall be incandescent as shown in the project plans~~.

4. All signal and pedestrian indications shall be light emitting diode (LED) modules. The LED modules shall meet or exceed the current Institute of Transportation Engineer's LED standard

   ~~a.Incandescent optical assemblies shall consist of a reflector, lens, socket, bulb, gasket, etc. Optical assembly shall be in compliance with Institute of Traffic Engineers (ITE) Standard for Adjustable Face Vehicle Traffic Control Signal Heads, or the Standard for Adjustable Face pedestrian Signal Heads.~~

   ~~1) Reflector: Parabolic, Alzak with suitable retainers, and gaskets.~~

   ~~2) Lens: Made from glass. Arrow indications may use arrow mask or painted legend.~~

   ~~3) Socket: Fixed focus with axial adjustments for proper filament position.~~

   ~~4) Bulb: Traffic Signal Bulb with brass base, 8000 hour rated life, 130 VAC rated voltage.~~

   ~~a)Filament shall be supported at each end plus a minimum of four intermediate points.~~

   ~~b)Bulbs shall be in compliance with ITE Standard for Traffic Signal Lamps.~~

   ~~c)Bulbs shall be Sylvania or prior approval equal.~~

   ~~d)Bulbs in 12 in. sections shall be 135 watt, 3-inch center length.~~

~~e)Bulbs in pedestrian sections shall be 67/69 watt, 2-7/16 inch light center length.~~

~~f)Bulbs shall be installed with the open end of the filament in the "up" position.~~

4. Each circular signal section shall be furnished with a tunnel type visor and shall be attached to the door front using four (4) stainless steel screws, which shall thread into a brass thread insert. ~~Pedestrian visors shall be a Z-crate design.~~

5. A suitable terminal block shall be provided in each signal assembly to terminate socket wires with incoming field circuits.

6. A back plate shall be furnished with each vehicular signal face forming a 5-inch border around the perimeter of the signal. Back plates shall be one-piece, louvered, vacuum formed ABS plastic. The bottom segment shall be split for ease of installation and joined with stainless steel screws. The side exposed to traffic shall have a dull or hair cell finish. 3-section signals shall use a 2-piece, non-louvered plastic back plate. The plastic material shall be 0.125 in. thick flat polyethylene with ultra-violet inhibitors. The side exposed to traffic shall have a dull finish.

7. Signal head bodies shall be federal yellow in color. Door, visors, and backplanes shall be dull black.

8. Signals mounted on mast arms shall utilize a universally adjustable mast arm Astrobrac mounting assembly. It shall be unpainted aluminum or galvanized finish.

9. Signals mounted on side of pole or top of pedestal pole shall use industry standard locking brackets made from 1 ½ in. aluminum pipe and appropriate locking fittings. Attachment to signal heads shall be with tri-stud type hardware. Exposed pipe and hardware shall be painted federal yellow.

10. Vehicular signal heads must meet requirements of the ITE Standard: "Vehicle Traffic Control Signal Heads". Pedestrian signal heads must meet requirements of the ITE Standard: "Pedestrian Traffic Control Signal Indications".

11. Signal heads shall be mounted at a ninety (90) degree angle to the road surface.

92.3 CONSTRUCTION REQUIREMENTS

A. General

1. The contractor shall furnish and install all material and equipment for Traffic Signals and Roadway Lighting as required by the plans and specifications.

2. Equipment and materials furnished shall be new.

3. The Contractor shall contact all utility companies to determine their involvement within the project limits and to notify them of the date that work is to begin. The Contractor shall contact the One Call Center at least 48 hours prior to excavating.

4. All work shall be in compliance with City, local utility, and NEC requirements (latest revisions).

B. Underground conduit

1. Conduit shall be placed by jacking, drilling, or trenching. Trenching under existing pavements will only be allowed with the approval of the Engineer.

2. Conduit entering through junction or pull box walls shall terminate approximately two inches in from the inside wall and not less than two inches above the bottom.

3. Conduit entering the traffic signal cabinet shall be sealed with paraffin or other approved sealing compounds to prevent the entrance of gases.

4. Nonmetallic conduit open ends shall have an approved bell end or bushing installed to prevent damage to cable or conductors.

5. Metal conduit open ends in junction boxes or above concrete foundations shall be provided with an approved threaded conduit grounding bushing.

6. Metal conduit ends shall be reamed to remove sharp edges and burrs. Threads on threaded conduit shall be painted with a good quality lead or rust preventive paint as the couplings are made up. Couplings shall be tightened until the ends of the conduit are brought together.

C. Junction boxes

1. Eighteen (18) inches of Type 2 Select Granular Backfill material shall be placed below the bottom of the junction box as foundation.

2. The top of the junction box shall be flush with hard-surfaced areas and approximately one inch above earth or grass areas.

D. Concrete Footings

1. The bottom of concrete footings shall rest on firm ground. The sides of the footings shall be formed by using an auger and then placing the concrete against undisturbed soil.

2. A suitable form shall be used above existing ground line and all exposed portions shall be formed to present a neat appearance. The above ground portion of the footing shall be formed of sufficient size and shape so no part of the pole or transformer base shall overhang or protrude beyond the footing.

3. An acceptable form shall be used if the excavation is larger than the standard footing dimensions. Backfill or a flow able fill must be placed to a density equal to or greater than adjacent undisturbed natural soil.

E. Underground Wire Installation

1. General

a. All underground wire installations shall run in conduits. No wire shall be pulled through a conduit housing existing wire. In such cases, all wire shall be removed and new wire installed.

b. Wire shall be installed using methods that will not injure the jacket, insulation, or conductors.

2. Traffic Signal Cable

a. There shall be no splices from controller to poles.

b. There shall be six (6) feet of cable slack provided in junction boxes.

~~b.~~c. Cable runs shall include a seven (7) conductor cable to the end of all overhead mast arms.

~~c.~~d. Cables pulled to the base of all signal poles shall have a minimum of twelve (12)~~four (4)~~ spare conductors.

e. Cable terminations in pole bases shall use 3M™ Scotchlok™314 wire connectors.

f. Wires from signal heads shall be labled with cloth type labels.

g. All wires entering the controller cabinet shall be color coded to each corner and bundled neatly.

F. Loop Detectors

1. General

a. Loop wire shall be continuous throughout the loop and lead-ins.

b. All wire connections shall be sealed and insulated with 3M™ Scotchcast™ 3570G Connector Sealing Packs.

~~b.~~c. The lead-in wires, from the loop to the junction box, shall have a minimum of three (3) twists per foot.

~~c.~~d. Loop lead-ins shall extend to a junction box. Lead-ins shall be long enough to provide a minimum of ten (10) feet of cable within the junction box. The wires shall be sealed to prevent the entry of moisture into the ends of the loop leads.

~~d.~~e. If unable to complete the installation, and it is necessary to leave the lead-ins exposed, the installer shall seal the wires to prevent the entry of moisture. Contractor shall protect the wires to ensure that the operational ability of the loop remains when final installation is complete.

~~e.~~f. Loops shall be ohmed out prior to installation to ensure continuity.

~~f.~~g. All loops shall be located as shown on the plans or as directed by the Engineer or Engineer's designee.

~~g.~~h. Where loop lead-ins enter the junction box, each loop shall be identified as specified, on the plans.

~~h.~~i. Each loop shall have four (4) turns of wire per loop, with ends reaching the junction box. There shall be no splices under the pavement.

~~i.~~j. Unless otherwise noted on the plans, the standard loop size is to be six feet by six (6 x 6) feet.

2. Sawed in Loop Installation

   a. Sawn slots in the pavement shall be blown out with compressed air and shall be clean and free of loose grit and moisture when wires are placed and sealer is applied.

   b. Slots shall be 1/16 in. to 1/8 in. wider than the outside diameter of the loop wire or tubing.

   c. The slot depth shall provide a covering of not less than ¾" in. above the uppermost detector wire tubing after the loop installation is completed.

   d. With the approval of the engineer, loop detector wire installations in new asphalt may be sawed and embedded with sealant in a subsurface course with subsequent covering by the surface course.

   e. The wire shall be laid in the slots so there are no kinks or curls and no straining or stretching of the insulation on the wire.

f. Loop wires or lead-ins shall be given extra protection at pavement joint locations. The extra protection shall consist of a 12 in. long piece of ¾ in. flexible tubing that fits snugly around the wires. Allow slack in the wires to install the hose or tubing. A longitudinal cut or slot may be made along the bottom of this material for ease of placing wires within hose or tube.

3. Preformed Loop Installation

a. All loops shall be secured in the base course material in such a manner as to remain in place during paving operations.

b. All loops disturbed or damaged during paving operations shall be replaced with in-kind preformed, under pavement loops.

c. Loops shall be buried in the gravel base with one to four inches of cover.

G. Poles

1. Poles shall be plumb when the installation is complete with anchor bolt nuts firmly tightened.

2. Field repair of damaged galvanizing shall be done in accordance with AASHTO M36.

END OF SECTION