CITY OF LAWRENCE, KANSAS
TRAFFIC ENGINEERING DIVISION
TRAFFIC SIGNAL SPECIFICATIONS

SECTION 1: CONTRACTOR PERSONNEL REQUIREMENTS

All contractors engaged in traffic signal construction for the City of Lawrence shall have a representative on the job at all times that has an International Municipal Signal Association (IMSA) Traffic Signal Level II certification. A copy of the certification shall be furnished to the city traffic engineer prior to award of the contract.

All contractors engaged in traffic signal construction and/or inspection shall have a cellular phone on the job site and operational during all construction activities. In addition, an "after-hours" contact name and phone number shall be provided prior to the beginning of any work. The contractor shall respond to service calls at all times within one (1) hour of notification.

SECTION 2: EQUIPMENT

A. TRAFFIC SIGNAL CONTROLLER: Each traffic signal controller shall be an EPAC 3108M52, manufactured by Siemens Traffic Control Systems, Austin, Texas.

The controller shall be delivered to the Traffic Engineering Offices, 445 Mississippi Street, a minimum of three (3) weeks prior to installation, for testing purposes.

B. MALFUNCTION MANAGEMENT UNIT (MMU): Each cabinet shall include a malfunction management unit (MMU) meeting all applicable requirements of NEMA specification TS-2 and the following requirements. The MMU shall operate in Type 12 mode with SDLC communications enabled.

The MMU shall include two high contrast, large area LCD displays to continuously show full intersection signal status and a separate LCD display to provide a graphic user interface to status, signal voltages and event logs. The event logs shall provide information as to time and date, complete intersection status, voltages, temperature, AC line events, etc. The MMU program shall include the use of help screens to assist in fault determination, which shall include trouble shooting suggestions. It shall include a 10/100Mbps Ethernet port for communication to a central office or to a laptop field computer. A software program shall be provided to allow the use of a computer to program the MMU, as well as to upload and store data logs, configuration settings, etc.

The MMU shall be Eberle Design Inc. model MMU-16LEip.

The MMU shall be delivered to the Traffic Engineering Offices, 445 Mississippi Street, a minimum of three (3) weeks prior to installation, for testing.

C. VIDEO TRAFFIC DETECTION SYSTEM: Each video traffic detection system shall be a Vantage Edge II Video Detection System, manufactured by Iteris, Anaheim, CA.

D. DETECTORS AND DETECTOR RACKS: Detectors shall be rack mounted units of solid state design and shall meet the following requirements.

The detector units shall comply with all requirements of Part 6 of NEMA Standards (latest version). Each detector amplifier unit shall be configured as a rack-mounted printed circuit board for insertion into a card cage and shall inter mate with an edge connector type Cinch 50-44A-30. Each unit shall operate from an external power supply and shall draw no more than 80MA of current at 24VDC +/- 20%.

Each loop input shall incorporate lightning and transient protection devices and the loop oscillator circuitry shall be transformer isolated to allow operation with loops which are grounded at a single point.

The unit front panel shall include two, high intensity, LED indicators. One shall indicate the detect status of the extended and delay timers (if used). The second shall indicate the status of the fault monitor circuitry as described elsewhere in this specification. Each channel shall be equipped with a three position toggle switch to allow the selection of three loop frequencies which may be used to eliminate crosstalk between loops connected to different amplifier units. Additionally, a three position toggle switch shall allow the selection of three modes of presence operation:

Pulse	125 ms +/- 25 ms
Short presence	15 minutes (restarts on vehicle entry)
Long presence	2 hours

Each channel shall be equipped with a 16 position thumbwheel type switch to allow selection of one of 15 sensitivity settings or channel off. Sensitivity settings shall be adjustable between the limits of 1.28% and .01% as follows:

Level 15	.01%	Level 10	.06%	Level 5	.32%
Level 14	.015%	Level 9	.08%	Level 4	.48%
Level 13	.02%	Level 8	.12%	Level 3	.64%
Level 12	.03%	Level 7	.16%	Level 2	.96%
Level 11	.04%	Level 6	.24%	Level 1	1.28%
Level 0	Channel OFF				

Each channel shall automatically tune to any loop/lead in combination within the range of 20 to 2500 microhenries having a Q factor greater than 5, and shall automatically and continuously track and compensate for component drift and environmental effects across the entire NEMA operating temperature range.

In order to reduce the potential for cross-talk between closely spaced loops connected to the same detector, the unit shall sequentially scan each channel so that only one channel is active at any given time.

The detector unit shall incorporate fault monitoring circuitry which shall continuously check the integrity of the loop. This monitoring circuitry shall detect open or shorted loops as well as sudden changes in inductance exceeding 25% of the nominal inductance of the loop/feeder network. If a fault is detected on a channel, an indication shall be provided in the form of a series of flashes of both the detect and fault indicators with each type of fault being identified by the sequence of the flashes. The fault indication shall be repeated until the fault is corrected and the detector unit is reset. Under fault conditions, the channel output shall remain in the detect state.

If required, the detector units shall be equipped with delay and extension timing which may be activated and adjusted by setting board-mounted switches on the unit. Delay timing shall be adjustable in 1 second increments up to a maximum of 63 seconds. Extension timing shall be adjustable in 0.25 second increments up to a maximum of 15.75 seconds.

Each channel shall provide an optically isolated, solid state output rated at 80VDC capable of carrying 100 ma of current. The isolation provided by the optical coupler shall exceed 7500 VAC.

Each rack shall be fabricated of aluminum and shall provide adequate support and protection for the detector units installed therein. Each rack shall mount no more than eight (8) detector units. Multiple racks shall be provided if more than eight (8) detectors (16 channels) are required. The rack shall be equipped with card edge type socket connectors spaced on 1.2-inch centers to connect the detectors to the system. All wiring connections to the detectors shall be done through these card edge connectors. Each detector unit position within the rack shall be fitted with a non-conductive card guide on both the top and bottom to guide the card into the socket to facilitate insertion. Card guides shall be held positively in place in the rack members.

Each rack shall be equipped with a plug-in power supply capable of providing 24 volt DC power to a minimum of eight (8) two-channel detector units. Power supply shall be four-channel devices having each channel separately fused to provide protection from over current conditions. Each channel shall be equipped with an indicator LED to provide a visual indication of the channel operation.

The contractor shall tune all detector amplifiers to optimum performance at the time of system "turn-on".

E. EMERGENCY VEHICLE PREEMPTION SYSTEM: The preemption system shall detect emergency vehicles equipped with a strobe light designed to output light pulses having both specific repetition rates and pulse rise times. The preemption system shall not directly control the traffic signals at an intersection, but rather shall provide a unique control signal to the traffic signal controller which may then act upon that control signal in a prescribed manner. The emergency preemption system shall contain two elements: optical detectors and a controller interface card.

Each optical detector unit shall be a dual priority device capable of identifying and responding to either high priority strobe light pulses within the frequency range of 14.0265 Hz and 14.0681 Hz, or to low priority strobe light pulses within the frequency range of 9.6332 Hz and 9.6718 Hz. Light pulses falling outside the frequency limits will be ignored by the system. The optical detector unit shall have a minimum range of 2500 feet.

The output signal shall be steady state in the case of a high priority detection or shall be a 6.25 Hz +/- 0.1 Hz square wave in the case of a low priority detection. A high priority detection shall immediately override a low priority detection and the output shall transfer to the high priority state. Detector outputs may be directly paralleled in order to provide a greater area of coverage in unique road situations. No additional interface equipment shall be required to provide this type of connection.

The detector unit shall operate from a power source of 12 to 40 VDC. The unit shall operate properly and reliably over a temperature range of -34C to +74C.

The unit shall be housed in a UV stabilized, polycarbonate housing. A sight tube shall be side-mounted to the housing. The unit shall be provided with a weep hole to allow the escape of condensation.

The detector head housing shall be mounted on a single mount die-cast weather resistant conduit body.

The preemption system controller interface/phase selector cards shall be a solid state unit which shall provide a minimum of two optically isolated channels, each capable of operating a minimum of three optical detector heads. It shall also provide all operating power supply voltages for the optical detector heads. The unit shall be an edge connected circuit card having a physical size identical with conventional 2 channel card rack style vehicle loop detector units so that it may be incorporated into the same card rack. The interface card shall operate over the range of 95 to 135 VAC, 60 Hz.

The unit shall operate over a temperature range of -34C to +74C.

The interface card shall include LED pilots to indicate power on and individual indications for each channel to indicate detection. Additionally, each channel shall include a means to simulate a detector call for test purposes.

Interconnection between the optical detector heads and the interface card shall be by means of a three conductor, 20AWG, individually tinned copper stranded cable. The cable shall be shielded with an aluminized polyester film which shall provide 100% coverage. A 20AWG drain wire, stranded, uninsulated, and in contact with the shield shall be provided, except in preempt head it shall be taped to prevent shorting at terminal buss.

The cable shall include an outer jacket of PVC having a nominal thickness of .045" and a nominal OD of .35". The jacket shall have a voltage rating of 600V.

The contractor shall set-up and test all emergency preemption equipment prior to turn-on.

F. CONTROLLER CABINET: The controller cabinet shall be delivered to the Traffic Engineering offices, 445 Mississippi Street, a minimum of three (3) weeks prior to installation.

The controller and all associated equipment shall be furnished completely housed in a sturdy aluminum cabinet. The cabinet shall be of clean cut design and appearance having no sharp edges, corners or projections. The size of the cabinet shall be such as to provide ample space for housing the controller and all associated electrical and auxiliary devices. A hinged door shall be provided permitting complete access to the interior of the cabinet. The cabinet is to be weather-proof and dust tight. The door shall be provided with a strong lock and two (2) sets of keys. The door hinges and pins shall be of non-corroding material.

A heavy "zip-lock" print sack shall be attached to the inside of the main cabinet door. A blank self-adhering field connection hook-up chart shall also be supplied and attached to the inside of the main door.

An 18-inch cabinet base extension manufactured of the same material as the cabinet, having the same cabinet dimensions shall be supplied and installed under the cabinet. All mounting hardware to attach cabinet and base shall also be supplied, along with a gasket material between the cabinet and the base. The extension shall have a removable front panel with gasket.

The controller cabinet shall be supplied with three (3) complete sets of prints (one contractor, two City of Lawrence). The supplier shall red line both City prints with any cabinet wiring changes made, along with an explanation of the changes.

The cabinet shall contain strong mounting shelves for the support of the controller and associated equipment.

A solid-state two-circuit jack mounted flasher with a rated load of 10 amps per circuit shall be supplied. Where additional load is required, more than one (1) flasher will be provided. The flasher shall flash at the rate of 50-60 flashes per minute and be of the zero-switching type to prevent radio interference.

The cabinet shall contain a ventilating fan controlled by a thermostat and shall include suitable dust filters for the capacity of the ventilating system. The filters shall be of the dry type and easily replaced.

In addition to the main door of the controller cabinet, there shall be an auxiliary door provided in the main door with a lock, lock cover, and standardized police key. The panel behind the auxiliary police door shall contain one (1) switch, one (1) connection jack, and one (1) plug-in manual control push-button with 6 foot coil-type cord, to accomplish the following functions:

(1) Change from normal operation to flashing, and vice-versa.
(2) Manual push button connector jack wired such that insertion of the plug-in manual control cord shall automatically apply a manual control enable input.

A 120v duplex receptacle outlet and trouble lamp fixture shall be furnished with each cabinet. These shall be protected with a 15 amp breaker.

The cabinet shall contain an internal test panel, located on the back of the door, which shall have the following switches (all switches and switch positions shall be clearly marked):

(1) One (1) Stop Time-Run-Normal Test switch.
(2) Controller power on-off switch.
(3) Change from normal operation to flashing operation and vice-versa.
(4) Interrupt power to the signal.

Each cabinet shall include a terminal facility which shall incorporate four major sub-sections:

(1) Detector terminal panel located on the cabinet left wall.
(2) Terminal panel for the connection of input/output circuits to the "D" connector located on the cabinet left wall.
(3) Main terminal panel located on the cabinet rear wall.
(4) Power distribution panel located on the cabinet right wall with capabilities of connection to #6 stranded copper wire on AC-, AC+, and safety ground.

The detector terminal panel shall incorporate sufficient terminals for the connection of all incoming loop feeder cables and all pedestrian pushbutton wiring. All field connections shall terminate on barrier style terminal blocks having minimum 8-32 screws and rated at not less than 30 amps per circuit. A ground buss to facilitate the connection of feeder cable shield wires shall be provided adjacent to the field terminal strips. All detector connection harnesses shall be terminated on this panel. Terminal points for AC+, AC-, and phase greens shall be provided. Each vehicle detector feeder connection shall be equipped with a lightning arrestor of the inductive type having a maximum resistance of not more than 150 milli-ohms and an inductance of at least 4 milli-henries. The arrestor shall be a two-stage, three-terminal device capable of clamping a 250 ampere surge to 25 volts within 40 nanoseconds when applied across the detector leads and to 35 volts when applied across the detector lead and ground.

The "D" connector panel shall provide sufficient terminals for the connection of all incoming and outgoing circuits from the controller "D" harness. All circuits shall terminate on barrier style terminal blocks having a minimum 8-32 screws and rated at not less than 30 amps per circuit.

The main terminal panel shall include the following:

(1) Terminal points for all input/output connections for the "A", "B", and "C" connectors from the controller.

(2) Wired positions for a two-circuit NEMA flasher and three-circuit NEMA load switches in the following quantities:
8-phase facility - 16
4-phase facility - 8
2-phase facility - 4
(3) Wired positions for flash transfer relays in the following quantities:
8-phase facility - 8
4-phase facility - 4
2-phase facility - 1
(4) Termination points for all field signal wiring.

All wiring to and from the NEMA "A", "B", and "C" connectors shall be routed directly to, and shall terminate on the rear of the main terminal panel by means of a soldered connection to a feed-through style terminal block such that all input/output circuitry shall be accessible from the front of the panel for test or hook-up purposes. To insure the reliability of these circuits, no plugs, sockets, printed circuit boards or push-on type connectors shall be inserted between the controller plugs and/or sockets and the terminal strip points at which these wires are terminated. Additionally, all load switches input circuits and conflict monitor control circuits shall terminate by means of solder connections to these same terminal strips. Thus it shall be possible to make the interconnections between the controller, load switches and conflict monitor by means of a simple system of jumpers located on the front of the main panel such that alterations may be easily accomplished.

All load switch, flash transfer relay and flasher sockets shall be wired with solder connected conductors, properly sized as to their function. Each load switch socket AC+ input shall be wired individually to the main AC signal buss with a minimum 16AWG conductor.

All field signal connections shall be terminated to a heavy duty, barrier style terminal strip having minimum 10-32 screws. All terminal connection points shall be clearly identified as to their function and referenced to the terminal facility wiring diagram by means of clear, silk screened legends located on the panel adjacent to the appropriate terminal point. All signal phases shall be equipped with provisions to allow the selection of either red or yellow flash programming. Flash programming shall be accomplished by the simple rearrangement of jumpers which shall require nothing more than simple hand tools to perform.

A power distribution panel shall be located on the right side wall of the cabinet in the case of 4- and 8-phase terminal facilities. In the case of 2-phase terminal facilities, all of the following specifications shall be applicable except that the componentry shall be incorporated on the main terminal facility to conserve space within the cabinet. The assembly shall contain provisions for the connection of the incoming AC service, a main cabinet circuit breaker, a radio interference line filter having a current carrying capacity equal to or greater than the main circuit breaker, a lightning arrestor and a mercury buss relay to control the AC power to the signal heads.

The main AC service circuit breaker shall be rated as follows:

2-phase terminal facility	30 ampere
4-phase terminal facility	30 ampere
8-phase terminal facility	50 ampere

The lightning arrestor shall be of the hybrid type rated at 20,000 amps and capable of clamping such a surge to a peak of not greater than 350 volts without regard for the rise time of the surge. The arrestor shall be totally of solid-state design, with no gas tube type devices of any kind, and shall be a two-stage unit providing separate protection for the controller and conflict monitor unit. A minimum 200 micro-henry inductor shall be incorporated between the equipment line-in and equipment line-out terminals. The arrestor shall be epoxy encapsulated in a flame retardant material.

The mercury buss relay shall have a current carrying capacity at least as great as the main circuit breaker and shall be of the normally open type wired such that under normal stop and go operation of the controller, the relay shall be held energized and shall allow current flow to the load switches under that condition. De-energization of the buss relay shall disconnect power to all load switches.

All cabinets shall be provided with weatherproof detector loop identification strips installed on the shelf lips, immediately above and below the detectors.

The cabinet shall be supplied with a Novus 1000TP uninterruptible power supply with an Alpha MBP bypass, an Alpha BSM-4 battery side module, and four (4) AlphaCell 180GXL-4 batteries, manufactured by Alpha Technologies, Bellingham, WA.

G. POLYCARBONATE VEHICLE SIGNAL HEADS: All vehicle signal heads shall be manufactured of polycarbonate material and shall have 12-inch lenses.

The signal housing shall be screw injection molded of polycarbonate resin and shall be of sectional construction to permit the installation of the number of sections specified on the plans or bid document, and to allow the installation of additional sections for future needs. The top and bottom of each section shall include mounting holes sized to accommodate standard 1-1/2-inch signal mounting hardware. Each mounting hole shall be surrounded with molded-in serrations to provide a positive lock between the individual sections of the signal and between the signal head assembly and the mounting bracketry. The serrations shall provide 5 degree increments of adjustment to allow proper aiming of the signal. Signal sections shall be joined together with a minimum of four (4) bolts and locknuts located in a manner so as to distribute stress equally over the body ends. The inside surface of each body end shall be essentially smooth and flat. Any webbing or other protrusions which prevent the use of standard signal mounting hardware or which obstruct the use of normal installation tools shall not be permitted.

The signal doors shall be screw injection molded of polycarbonate resin. The doors shall be hinged to the body section on the left side using stainless steel hinge pins and shall be equipped with a substantial screw or wing nut type fastener of stainless steel material on the right side to provide a secure closure means. Both the hinge and closure device shall be internal to the signal body and shall not protrude from the body side in any way.

Both the hinge pins and the closing fasteners shall be held captive to the door for ease of maintenance. In the closed position, the hinge pins shall be positively locked in place to preclude their falling out due to vibration.

Each door shall be fitted with a tunnel type visor which shall, at its base and extending approximately 1-1/2" from the door surface, totally surround the lens to provide strength. Beyond this strengthening ring, the bottom portion of the visor shall be removed to form a "tunnel". All visors shall be of polycarbonate resin and shall be molded with four (4) ribs extending outward from the door surface for added rigidity. Tabs shall protrude at right angles to the side of the visor to provide attachment to the signal door, and to allow their easy removal or replacement. All visor mounting hardware shall be of stainless steel. Signal head assemblies shall be supplied with all visors attached.

The lens in each signal head shall be an LED self-contained, sealed unit designed to fit a regular 12-inch traffic signal housing, and shall meet the latest applicable specifications of the INSTITUTE OF TRANSPORTATION ENGINEERS. The lens shall provide a light beam spread of 30 degrees on all sides of its center axis which shall be designed to provide a five (5) to seven (7) degree downward angle. The lens shall be made of UV stabilized acrylic or UV stabilized plastic. The rear cover shall be of nonflammable material and the entire unit shall be totally sealed to preclude the entrance of water, dust or any other contaminant. The unit shall consume less than 30 watts of power. Light output shall be comparable to that provided by a standard 12-inch traffic signal illuminated by a 150 watt incandescent lamp. The manufacturer shall warrant the unit against defects in workmanship and material for a period of at least five (5) years after date of delivery, and shall be assigned to the City of Lawrence.

Each signal head shall be equipped with one (1) or more terminal blocks to facilitate the electrical hook-up. All terminal blocks shall be separate and removable components which shall provide minimum 8-32 screws for all wiring connections. Signal head assemblies of three (3) or fewer sections shall include one (1) terminal block; four (4) and five (5) section signal heads shall include two (2) terminal blocks.

All internal signal head wiring shall be color coded appropriately to indicate the function of each lead without the need to individually trace them.

The color of each component of the signal head assembly shall be molded throughout the thickness of each part. The underside of each visor shall be dull black. The body shall be black and all other components, including mounting hardware, shall be black or natural aluminum. No painting will be allowed.

H. PEDESTRIAN SIGNAL HEADS: Pedestrian signal heads shall consist of a single piece polycarbonate housing, a two-symbol two-color message module with countdown timer, a single piece polycarbonate swing down door frame, and appropriate sockets and other hardware.

The pedestrian signal head shall be capable of displaying, brightly and uniformly, the alternate message symbols full "HAND" in portland orange and full "PERSON" in white while being subject to strong ambient light conditions; the messages shall "blankout" when not energized.

The symbol indications shall be an LED module meeting all applicable specifications of the INSTITUTE OF TRANSPORTATION ENGINEERS. It shall incorporate high intensity LED's in a sealed watertight unit designed to fit into the pedestrian signal housing. The countdown timer shall countdown the DONT WALK phases only; the WALK phase countdown timer (if present) shall be disabled at the factory. The module shall operate over a voltage range of 89 to 135 volts AC and consume less than 12 Watts of power. The module shall have an operating temperature range of at least -34C to +74C. The light output shall be comparable to that of a standard pedestrian signal illuminated by a 90-Watt incandescent lamp. The manufacturer shall warrant the module against defects in workmanship and material for a period of five (5) years after date of delivery, and shall be assigned to the City of Lawrence.

The overall dimensions of the signal head shall be approximately 18-inches wide, 19-inches high, and 9-inches deep, including hinges, and all components shall be readily accessible from the front.

The inside of the module shall be fitted with a one piece sponge neoprene gasket fitted around the perimeter such that a weatherproof seal is afforded whenever the module, door, and case are properly mated.

The mounting hardware shall be a two-piece, cast aluminum alloy assembly. The two separate castings shall be joined in the final assembly by the use of stainless steel spring pins. The spring pins shall be factory installed into the hinge ears which shall be integrally cast into the "pole half" of the assembly. Final mating of the two halves shall be accomplished by inserting the spring pins into the drilled hinge ears of the head half of the assembly.

Unit construction shall allow for the through-bolt, bolt to tapped pole, lag screw, and band-it type mounting. The bolt hole shall be elongated from side to side and the recessed shoulder shall be curved to allow rotation of the installed assembly 15 degrees in either direction from center (when installed on a 4-inch pole).

Three (3) sets of screw terminal pairs shall be located on a terminal block in the head half of the clamshell assembly. A corresponding rain shield shall be provided in the pole half to prevent water entrenchment onto the terminal block. A closed cell neoprene sponge gasket shall be provided on the mating surfaces of the two halves of the assembly to complete the rain tight construction. Provisions shall be provided to allow wiring to the field wires by conventional screw type terminals. Field wires shall be either AWG 12 or AWG 14.

I. TRAFFIC SIGNAL BACKPLATE: When called for on the plans or bid documents, signal heads shall be equipped with backplates meeting the following minimum standards.

All backplates shall be one (1) piece, vacuum formed construction. They shall be molded of 0.125 inch ABS material having a "hair cell" finish on the front surface and a flat finish on the rear side. Backplates shall be black in color and shall be molded to conform to the general outline of the rear of the signal head to which they are to be attached. Backplates shall provide five (5) inches of increase target area around all sides of the signal head. To provide increased rigidity, each backplate shall be molded with a stiffener lip of approximately one (1) inch width which shall completely surround both the inner and outer edges of the backplate.

Each backplate shall be supplied with appropriate mounting hardware which shall include a minimum of four (4) fasteners for each signal head section of which the backplate is intended. Each fastener assembly shall include an appropriately sized bolt, a stop nut and a large "fender" washer to increase the bearing surface of the fastener to the backplate.

J. ALUMINUM TRAFFIC SIGNAL PEDESTALS: Unless otherwise specified on the plans, the following specifications shall govern the design of aluminum traffic signal pedestals.

The shaft shall be a one-piece tube of 6063-T6 aluminum alloy with a minimum wall thickness of 0.237 inches. The shaft shall be of uniform diameter throughout its length. The shaft outside diameter at the top shall be approximately 4.5 inches. Overall height of the shaft and base shall be as indicated on the plans. The shaft shall have a satin brush finish. The shaft shall be threaded with a nominal 4-inch pipe thread and be threaded into the base and provided with a strengthening collar.

The base shall be equipped with a hand hole and door for access to the interior of the base. The hand hole shall have a minimum dimension of 7-3/4-inch by 8-inch. The door shall be aluminum and fastened in place by a single bolt which shall have an "allen" head to discourage unauthorized personnel from gaining access to the wiring compartment in the pedestal base. The pedestal base shall be mounted to a poured concrete pad by means of four (4) anchor rods set in a bolt circle of 13-1/2-inch diameter. There shall be a provision in the base for the attachment of a ground rod.

Anchor bolts shall be 3/4-inch diameter by 27-inch long plated, and they shall be supplied with nuts, lock washers and flat washer.

The pedestal and base shall be designed to support two (2) one-way, three-section, 12-inch polycarbonate traffic signal heads, and two (2) 16x18-inch cast aluminum pedestrian signal heads and shall be equipped witha Pelco Collar (PB-5325).. The shaft shall be wrapped with protective paper for shipment. Large scratches or gouges in the aluminum material will not be permitted.

K. BRACKETS AND MOUNTING ATTACHMENTS: Brackets shall be furnished in accordance with the plans or bid documents.

All side of pole brackets shall be molded of polycarbonate and shall incorporate a mounting arm and pole plate into a single member which shall include "molded-in" grooves to correctly position the banding material on the pole plate. Grooves shall extend completely across the face of the pole plate portion of the molding. The use of glued-in guide pins or other such methods of ensuring the correct location of the strapping material will not be permitted. The bracket shall be designed to provide a wiring raceway for signal cables exiting the support pole and entering the signal head. All hardware used to fasten the signal head to the bracket or close any unused opening shall be aluminum.

All mast arm signal mounting brackets shall be fabricated entirely of aluminum and shall provide for signal aiming adjustment in all planes. The brackets shall be designed to strap to the mast arm using rust-proof stainless steel twisted cable. The brackets shall incorporate wiring channels so that after installation, all signal cables shall be protected from the effects of exposure to the weather.

L. ELECTRICAL WIRE AND CABLE: All wire and cable supplied under this specification shall be approved based upon catalog cuts submitted to the engineer. In addition, all wire and cable shall be visually inspected by the engineer. Any apparent defect that may shorten the service life of the wire or cable will not be permitted.

(1) Shielded Detector lead-in electrical cable: #14 AWG (stranded), polyethylene, 2/C, IMSA 50-2.
(2) Loop detector wire: #14 AWG (stranded), THHN, IMSA 51-5. The loop wire shall be inserted into polyvinyl chloride (PVC) tubing prior to installation (one wire per section of tubing). The tubing shall have a nominal 3/16-inch inside diameter, a nominal 1/32-inch wall thickness, and shall be continuous.
(3) Multi-conductor cable: #14 AWG (stranded), THHN, IMSA 19-1. All conductor cable for intersection signalization and intersection interconnection shall be multi-conductor cable of the size specified on the plans.
(4) Power supply wire (load-side): Intersection signalization power supply wire (load-side) shall be a two-single conductor wire operation on a 600V maximum, and it shall be suitable for use at conductor temperatures not exceeding 75 degrees Celsius. Phase AC+ shall be insulated black or red in color. AC- neutral shall be insulated white in color. Material, construction and tests shall be in accordance with the applicable requirements of the ICEA Standard S-66-524 "Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy". Conductors shall be stranded, annealed coated copper. Copper wire before insulating or stranding, shall meet the requirements of the latest edition of ASTM B-33 (for coated wire). Stranding shall be Class B, in accordance with the latest edition of ASTM B-8. Wire sizes shall be as shown on the plans.
(5) Luminaire wire: Luminaire wire shall be two single conductors; one insulated red or black and the other insulated white; throughout the system. Conductors shall be stranded, annealed coated copper. Copper wire before insulating or stranding, shall meet the requirements of the latest edition of ASTM B-33 (for coated wire). Stranding shall be Class B, in accordance with the latest edition of ASTM B-8. Wire sizes shall be as shown on the plans.
(6) Video Cable shall be ISOTEC X531787-00. No substitute will be allowed.

M. MAST ARM STYLE TRAFFIC SIGNAL STANDARDS: Traffic signal support structures shall be steel "MonoLever" design and shall be of the size and type as detailed on the plans or bid documents. Structures shall provide an aesthetically pleasing appearance. The cantilevered arm shall slope upwards from the pole so that when fully loaded, the outboard mounted signal attachment point shall be no lower than 20 feet above the pole base datum and the arm shall continue to slope upward or shall as a minimum, appear horizontal. All structures shall be furnished with:

(1) Mast arm with mounting flange.
(2) Support pole with base plate and arm mounting flange.
(3) Anchor bolts with nuts and washers.
(4) Covers for the anchor nuts.
(5) Caps for top of pole and end of mast arm.
(6) All fastening hardware.

The complete assembly shall be designed to support standard multi-section signal assemblies, rigidly mounted with backplates installed in the locations as detailed on the plan sheets. All structures shall conform to the 1994 AASHTO "Standard Specification for Structural Support for Highway Signs, Luminaries, and Traffic Signals" Handbook, in accordance with the requirements for 90 MPH wind loading and shall include a 1.3 gust factor.

The shaft and mast arm shall be manufactured of United States produced steel only. Steel shall be hot-rolled and shall have a minimum yield strength of 55,000 PSI (Per ASTM 4595) after fabrication. Poles or arms up to 50 feet in length shall be fabricated of one (1) piece. All arms or poles shall have a full length longitudinal high frequency resistance weld and shall have a round cross-section and shall have a uniform taper of approximately 0.14 inches of diameter change per foot of length. Multi-sided poles or arms will not be permitted. Shaft lengths in excess of 50 feet shall be of two-piece, slip-joint construction. The overlap length of the slip joint shall be at least 1-1/2 times the maximum inside diameter of the outside shaft. A through bolt shall secure the slip-joint.

All poles shall be equipped with a hand hole of approximately 4-inches x 6-1/2-inches located approximately 24-inches above the base plate and oriented 180 degrees from the mast arm, and shall include provision for the attachment of a grounding wire. All poles shall be equipped with a hand hole and gasketed cover of approximately 4-inches x 6-1/2-inches located approximately just above center of mast arm flange and 180 degrees from the mast arm.

The arm to pole connection plate shall be fabricated of structural quality hot-rolled carbon steel plate having a minimum yield strength of 36,000 PSI. The mast arm plate shall telescope the arm shaft by welded gusset plates top, bottom and sides. Attachment of the arm to the shaft shall be via four (4) high-strength, galvanized, hex-head through bolts, nuts and appropriate washers.

All mast-arms shall include an auxiliary back-clamp designed and supplied by the manufacturer.

All poles, arms, and auxiliary back-clamps shall be hot-dipped galvanized after fabrication in accordance with ASTM A123.

A minimum quantity of four (4) commercial quality hot-rolled carbon steel anchor rods shall be furnished with each pole. Anchor bolt size and quantity in excess of four (4) shall be in accordance with the manufacturer's recommendation. All anchor rods shall have a minimum yield strength of 55,000 PSI and shall be galvanized a minimum of 12-inches on the threaded end. Rods shall have an "L" bend on the lower end. Each anchor shall be furnished complete with two (2) galvanized hex-nuts and two (2) galvanized flat washers.

A 1in. diameter x 1-1/2in. Long pipe nipple shall be welded in place between the lunimaire arm and mounting plate during fabrication. The cable entrance at the bracket arm shall be a field drilled 1-1/4in. Diameter hole.

N. SIGNS: Overhead street name signs shall be Type 5052-H38 aluminum alloy, 0.125-inch thick. The sign face shall be direct applied white and yellow (when required) super-high efficiency, full cube retroreflective sheeting, overlaid with green and black (when required) electronic cuttable film. The legend shall be centered on the sign face. All corners shall be rounded. Overhead street name signs shall be installed on mast arms, one foot from the signal pole, using stainless steel banding. **Note: The contractor shall provide a full size layout of each street name sign, for approval by the city traffic engineer, prior to fabrication.**

Pedestrian push button signs shall be 9"x15" R10-3e.

O. SERVICE BOXES, JUNCTION BOXES AND FIBEROPTIC VAULTS: All service boxes and junction boxes shall be pre-cast concrete with cast-iron lids, and shall have "TRAFFIC" or "TRAFFIC SIGNAL" cast on the lid, and provided with a lid hook hole. All fiberoptic vaults shall be 36"x24"x24" "RPM" polymer concrete, 20K "traffic" rated and shall have "TRAFFIC" or "TRAFFIC SIGNAL" cast on the lid.

P. PEDESTRIAN DETECTOR PUSHBUTTON: All pedestrian detector pushbuttons shall be Pelco #SE-2005-08, or approved equal.

SECTION 3: INSTALLATION

A. GENERAL: This specification is intended to describe equipment, material, construction procedures, and requirements for the installation of a traffic signal. The installation shall include all poles, bases, junctions boxes, wiring, signal heads, detectors and such other miscellaneous parts or materials as shown on the plans or as otherwise required or specified.

The contractor shall be responsible for furnishing and installing all equipment and materials necessary for the complete and satisfactory operation of the traffic signal, whether said equipment is specifically mentioned or not. All materials shall be new and comply with the latest edition of the National Electrical Manufacturers Association (NEMA) Standard No. TS-1.

The contractor shall contact any and all local agencies having jurisdiction over such installations and acquire any permits or licenses that may be required. A copy of each permit or license shall be furnished to the engineer prior to beginning any work at the job site. The contractor shall comply with all local ordinances or applicable building codes.

The contractor shall be responsible for properly locating all work to be done in accordance with the lines, grades, and elevations as shown on the plans. Any work done without being properly located and established by base lines, offset stakes, bench marks, or other basic reference points acceptable to the engineer, may be ordered removed and replaced at the contractor's expense.

The contractor shall notify the appropriate power company prior to beginning any construction to determine service location, type and method of hook-up. Meter and disconnect location shall be determined by the city traffic engineer. Where street lights are installed on traffic signal poles, the street light service shall not be metered and shall be supplied with a separate disconnect at the meter location. The meter socket and disconnect shall be installed as early in the construction process as possible so service can be connected for testing of traffic signals and street lighting. When the meter socket is installed, the contractor shall request an inspection from the City Planning and Development Services Department. The contractor shall be responsible for meter application and paying all hook-up fees.

In so far as is practicable, major items of electronic equipment such as the traffic signal controller and conflict monitor provided and installed under this contract, shall be of one type and consist of products from the same manufacturer and/or distributor in order to secure uniformity, single responsibility, and satisfactory service. The contractor shall deliver the controller cabinet, controller and conflict monitor to the City of Lawrence at least three weeks prior to installation, for testing purposes.

The contractor shall notify all utility companies which may have facilities in the work area. All City of Lawrence Departments that may have facilities in the area shall be contacted directly by the contractor. The contractor shall be responsible for locating any sprinkler systems in the area.

Any adjustments in elevation of service boxes, etc., required, shall be the responsibility of the contractor.

All rock used under service boxes, junction boxes and cabinet base shall be 1.5" washed screened aggregate.

The contractor shall be responsible for proper traffic control through the construction area at all times. A traffic control plan shall be submitted to the engineer for approval prior to beginning any construction. The entire cost of this traffic control, including, but not limited to signs, barricades, barriers, cones, drums, vertical panels, and flagmen, shall be the responsibility of the contractor. All traffic control devices and their use shall comply with the latest edition of the Manual on Uniform Traffic Control Devices.

The contractor shall arrange for the supplier of the major items of electronic equipment to have a representative at the site prior to and during energizing the traffic signal.

The contractor shall be responsible for the care of all signal equipment being installed or removed and shall dispose of or deliver the equipment to locations as specified on the plans or as directed by the city traffic engineer. All equipment shall be disassembled prior to leaving the construction site.

The contractor shall be responsible for final grading, seeding and mulching, or sodding, of the entire work site, as directed by the engineer. The contractor shall be responsible for policing the entire construction site of all trash, debris, etc.

The contractor shall be required to repair the settling of any trenches, pull boxes, etc., for a period of one (1) year after acceptance by the City.

The contractor will be allowed to close lanes of traffic between the hours of 9:00 am and 3:00 pm only, unless otherwise authorized by the engineer.

B. TRAFFIC SIGNAL IMPROVEMENT POLICIES: The work included in this project may involve replacement and/or modification of existing traffic signal equipment. At a location which is presently controlled by operating traffic signals, the following policies are to be observed during the modifications and improvements.

(1) The contractor shall provide continuous operation of the traffic signals during the signal modifications and improvements except for shutdowns to allow for alterations as required for installation of the improvements.
(2) Some periods of disruption of existing signal operation can be tolerated during installation of the improvements; however, the contractor shall coordinate any planned disruption of signal operations with the engineer a reasonable time in advance of such disruption of operations.
(3) Planned disruption of signal operations shall be limited to the hours between 9:00 am and 3:00 pm. The signal controls shall be operable during all other periods.
(4) All existing wiring within existing controller cabinets shall be identified by the contractor and each conductor properly labeled prior to de-energizing the existing controller to install the modifications and improvements.

C. SALVAGED EQUIPMENT: When salvaged equipment is to be reinstalled, the contractor shall furnish and install all necessary materials and equipment including anchor bolts, nuts, washers, concrete, etc. required to complement the salvaged equipment in the new installation.

When salvaged equipment is not to be reinstalled, it shall be removed, protected from damage, and delivered by the contractor to a location as directed by the city traffic engineer.

Existing bases for traffic signal poles, pedestals, and controller shall be removed a minimum of 24 inches below finished grade.

D. CONSTRUCTION SEQUENCE: The construction sequence for traffic signal installation shall be as listed below unless otherwise directed by the engineer. When traffic signals are being installed or modified in conjunction with major road construction or geometric improvements, no signal work shall be performed prior to the completion of all dirt work or paving unless directed by the engineer.

The contractor may submit written request(s) for modifications to this sequence to the engineer for consideration of approval. No modification shall take place until written approval is granted by the engineer. All modifications shall be noted on the plans at the time of construction.

(1) Install conduit, service boxes and junction boxes.
(2) Install pole bases and controller pad.
(3) Install controller cabinet, poles, meter socket and disconnects.
(4) Install mast-arms.
(5) Pull all cable and wire.
(6) Install signal heads, signs, and preemption equipment.
(7) Terminate wiring. Check individual phase wiring with a fuseable link momentarily flashed to AC+ buss bar. Do this with all load switches and flash relays removed from cabinet. Check all street lighting for operation or 110 volts AC+ at point of connection to street light head. If street light heads are not yet installed, place the correct size wire nuts over wire ends and tape, after testing circuits.
(8) Install detector loops (if required).
(9) Notification: The engineer shall be notified at least one (1) week in advance of the date of signal turn on.
(10) Flashing: At locations without previous traffic signal control, the new traffic signals shall be flashed for approximately one (1) week prior to full operation.
(11) System turn on: The signal system turn on shall not occur on Fridays, weekends, or holidays, unless authorized by the city traffic engineer, and shall be completed prior to 3:00 pm on the day of the turn on. The supplier of the control equipment shall have a representative present at the signal system turn-on and when detector loops or video detection zones and the emergency vehicle preemption system are activated.

Poles and arms shall be installed without signal heads. Poles and arms shall be installed separately unless approved by the engineer. All signals shall be covered if not in full operation (NO EXCEPTIONS). The covering shall be black in color and shall consist of equipment designed for this purpose.

E. CONDUIT: All conductors shall be run between bases, junction boxes, pole bases and service boxes in conduit unless otherwise shown on the plans. The conduit shall be of the type indicated in the plans. If the plans do not specify the type of conduit, the contractor may install any approved conduit of the size noted in the plans, after receiving approval from the city traffic engineer, except as noted below. Conduit shall be of one type from outlet to outlet.

Conduit under existing pavement, sidewalk or driveways shall be installed using an approved jacking or boring method.

All conduit installed above ground shall be metallic. Conduit attached to bridges shall have expansion fittings installed at the end of the bridge and at each expansion joint on the bridge.

All metallic conduits shall be electrically bonded by a grounding bushing and ground wire as detailed in the plans.

Metallic conduit shall be galvanized rigid steel conduit meeting the requirements of A.N.S.I. C80.1. Metallic conduit fittings shall be zinc-coated and shall meet the requirements of A.N.S.I. C80.4.

PVC conduit shall be either Schedule 40 or Schedule 80 rigid polyvinylchloride meeting the requirements of the latest edition of N.E.M.A. Standard TC-2. PVC conduit fittings shall meet the requirements of N.E.M.A. Standard TC-3 and shall be fabricated from polyvinylchloride having the same chemical and physical properties as the conduit with which it is to be used. The conduit and fittings shall bear the U.L. label.

The PVC conduit joints shall be made in accordance with the manufacturer's recommendations.

Polyethylene conduit shall be used under all pavement and shall be coilable, smooth wall, Schedule 40 or Schedule 80, high density polyethylene duct meeting the requirements of N.E.M.A. Standard TC-7.

Polyethylene conduit shall be continuous from outlet to outlet with no splices allowed. Bend radii shall not exceed the manufacturer's recommendations.

Conduit set in bases shall extend a minimum of two (2) inches and a maximum of four (4) inches vertically from top of base cap into bottom of pole. A cap of the correct size shall cover ends of all conduits prior to pulling wire. Conduit entering through the bottom of pull box shall be located to leave the major portion of the box clear. Conduit shall extend vertically into the pull box high enough to keep out water and silt but not high enough to crimp wire between conduit and pull box lid. Conduit entering concrete service boxes shall not extend more than four (4) inches inside and shall be neatly grouted with mortar. Conduit shall be sloped to drain as directed by the engineer. At all outlets, conduit shall enter from the direction of the run.

Whenever possible, the conduit shall be installed by trenching, and trenches shall run in straight lines between pull boxes and bases. The location of conduit shall be shown on the plans, except that where physical obstructions dictate, the location shall be determined by the engineer. Any additional lengths of conduit shall be at the contractors expense. Any changes shall be noted by the contractor and shown in red on the "as-built" plans upon acceptance of the project by the City of Lawrence.

Conduit shall be installed to a depth of at least 24 inches below finish grade unless otherwise directed or approved by the engineer. Exact depth shall be shown on the "as-built" plans.

Trenches shall be backfilled with material free of rock and debris, and compacted in lifts. If a density is not specified on the plans, trench backfill shall be compacted until, in the opinion of the engineer, no significant future settlement will occur. Red safety tape with the wording "CAUTION ELECTRIC LINE BURIED BELOW" shall be incorporated in the backfill at a depth of 12 inches below finish grade.

Existing underground conduit used as a part of the project shall be cleaned and blown out with compressed air.

F. CONCRETE BASE FOR POLES AND CONTROLLER CABINET: Bases for poles and cabinets shall be reinforced concrete as shown on the plans. The concrete shall be commercial grade. The reinforcing steel shall be free of rust and dirt and shall be of the size, number, and dimensions shown on the plans.

Anchor bolts shall be of the size and design recommended and supplied by the manufacturer of the pole or cabinet to be installed. They shall extend uniformly above the top of the concrete base a height as recommended by the manufacturer. Anchor bolt "Stabbing" will not be permitted.

A 3/4" x 10"-0" copperweld ground rod shall be installed at each pole base and at the controller pad.

The location of the bases shall be as shown on the plans. Any variation from the plan location shall be approved by the engineer in writing, and shall be shown on the "as-built" prints at time of change.

Traffic signal pole bases shall be constructed in two (2) pours. The initial concrete placement shall end six (6) inches below finish grade. A six (6) inch thick square concrete cap shall be poured when the pole has been erected and plumbed with bearing load. The top of the base shall be slightly (1/4"-1/2") higher than the adjacent top of curb or finish grade if no curb exists.

G. WIRING: When pulling conductors through conduits, a powdered soap stone, talc, or other approved lubricant shall be used. A pulling sock or other similar device shall be used to equalize pulling strain on the conductors.

Absolutely no splicing will be permitted in conduit or outside of pedestal bases with the exception of detector loop to detector feeder cable connections which shall be made in junction boxes, and common bonding ground explained in Section "L".

When conductors and cables are pulled into the conduit, all ends shall be taped to exclude moisture until the termination connections are made. Ends of spare conductors shall remain taped.

A minimum of six (6) feet of slack or excess cable shall be left in each service box for traffic cable, detector lead-in wire, video cable, and emergency vehicle preemption cable. A minimum of fifty (50) feet of excess fiber optic cable shall be left in each fiber optic vault. The excess cable shall be neatly coiled within the service box. Each cable shall be clearly marked with tape at each service box and J-box for identification (north, red; south, yellow; east, green; west, blue); a corresponding mark shall be provided at the cabinet. All cables and individual wires shall be marked with weatherproof flagstrips at the cabinet and termination point.

Wiring shall conform to the appropriate articles of the latest edition of the National Electric Code. The contractor shall pay particular attention to those sections of the National Electric Code which refer to grounding and bonding. Conduits shall not be filled to more than 40% capacity.

All conductors shall be a continuous run from controller box terminal to pole base with a minimum of three (3) feet slack left in each cable for termination in pole bases. A ground wire consisting of a #6AWG, stranded conductor, having green THHN insulation, shall be provided to bond all ground rods in the system together.

H. **SPLICES:** Splicing shall only be permitted in pole bases and detector lead-in pull boxes. The only exception will be street lighting conductors at service box junctions. Preemption cable splices shall not be allowed except in pole bases and must be approved by the city traffic engineer.

Splicing shall be accomplished by stripping the insulation from the conductor so when the appropriate size nylon insulated wing type wire connector is used, no uninsulated wire is visible. The splice shall then be encased in a waterproof dielectric greasepack (3M or approved equal). Street lighting in each pole base shall be spliced with wire nuts, taped and waterproofed.

When splicing is completed, it shall appear neat and uniform in length. All cable in all bases and pull-boxes shall be marked with a waterproof ink on a waterproof nylon cable marker flag strip. The information shall contain phase number and head number, push-button phase number and direction. Preemption cable shall be labeled for preempt number and direction. Loop wires shall be marked by loop number and phase number with a designation of "P" for presence and "S" for stretch. All single conductor cables in pole bases, such as signal service or street lighting wires, shall be marked in pairs.

After splicing and labeling, cables shall be cabled together and wrapped with a nylon cable tie. The bundle shall be neat in appearance and be easily removed from the pedestal base through the hand hole for inspection, service and testing. The cabling procedure shall include all cables within the pedestal base. Continuous run cables shall be looped through the bundle. All labels shall be clearly visible when the bundle is removed from the pedestal base.

NOTE: Splicing of coaxial video cable shall not be permitted under any circumstances.

I. **TERMINATION CONTROL BOX LOAD BAY:** Termination of the control box load bay shall be performed by the contractor.

J. **TERMINATION-POLE BASE:** All conductors within the pole base, with the exception of continuous runs, shall terminate as follows:

(1) All splicing shall be done through the pole base hand hole. After all multi-conductor cables have been trimmed to length, eighteen inches (18") of outer insulation of all cables entering the pole base shall be removed.
(2) Individual conductors of the multi-conductor cables shall be neatly sorted by the color-coding on the conductors as to Phase and/or operation and neatly bundled together
(3) Splicing of these bundled individual conductors shall be accomplished by stripping the insulation from the ends of each conductor, making sure the ends are even, and attaching an appropriate size **Nylon Insulated Wing-Type Electrical Spring Connector** (wire nut). No uninsulated wire shall be visible after tightening the wire nut.
(4) Conductors shall be connected as follows:

Vehicle Heads:

3-Section Heads:

NB, SB, EB, WB	**NBLT, SBLT, EBLT, WBLT**
Red-----Red	Red-----Red/Black Stripe
Yellow-----Orange	<- Yellow-----Orange/Black Stripe
Green-----Green	<- Green-----Green/Black Stripe

5-Section Heads:

(<-) Yellow-----Orange/Red Stripe (->) Yellow-----Red/Green Stripe
(<-) Green-----Black (->) Green-----Blue/Red Stripe

Neutrals-----White

Pedestrian Heads:

North/South
Dont Walk-----Red/White Stripe
Walk-----Green/White Stripe
East/West
Dont Walk-----Black/White Stripe
Walk-----Blue/White Stripe

Neutrals-----White/Black Stripe

Pedestrian Buttons:

North/South
Button-----Blue
East/West
Button-----Blue/Black Stripe

Neutrals -----White/Red Stripe

20 Conductor Cable directional color code:

North - Red, South - Yellow, East - Green, West - Blue

Preempt:

#1 - Northbound, #2 - Southbound, #3 - Eastbound, #4 - Westbound

Video Detection:

#1 - Northbound, #2 - Southbound, #3 - Eastbound, #4 - Westbound

K. **TRAFFIC AND PEDESTRIAN SIGNAL HEADS:** Traffic signal heads mounted on the side of poles or on pedestals shall be a minimum of ten (10) feet from the ground to the bottom of the signal head. Pedestrian signal heads mounted on the side of poles or on pedestals shall be a minimum of eight (8) feet from the ground to the bottom of the signal head.

Traffic signal heads mounted on mast arms shall be no less than 15 feet and no more than 19 feet from the pavement to the bottom of the signal head. The city traffic engineer shall direct the positioning of the signal heads. The wiring to the signal head shall not be fed through the bracket mounting. Each signal head shall contain two (2) coils of wire in the drip loop.

Field wiring shall be routed behind buss bar.

All signal heads shall be mounted on the back side of the pole or as directed by the city traffic engineer.

L. **POLE INSTALLATION:** When installed, the traffic signal poles shall be back raked according to the manufacturer's recommendation to allow for deflection so that the pole will plumb when loaded.

M. **LOOP DETECTOR INSTALLATION:** The field loop conductor installed in the pavement shall run continuously from the terminating service box, junction box, or base, with no splices permitted. The field loop conductor shall be spliced to the feeder cable and the feeder cable shall run continuously from the terminating service box, junction box, or base, to the detector sensing unit terminal.

All lengths of loop wires that are not embedded in the pavement, shall be twisted with at least five (5) turns per foot, including lengths in conduits and hand holes.

The electrical splice between the loop feeder cable to the controller and the loop wire, shall be made by the following method:

(1) Remove all feeder cable coverings leaving four (4) inches of insulated wire exposed.
(2) Remove 1/2-inch of the insulation from each conductor of a pair of feeder cable conductors.
(3) Remove 1/2-inch of the insulation from the loop wires. Conductors shall be joined by using the appropriate size nylon insulated wing type wire connector. The two splices shall be staggered to provide adequate insulation, then encased in a waterproof splice kit (3M DBY Splice Kit or approved equal).

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

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 saw cut shall have a depth of four (4) inches in asphalt and two (2) inches in concrete. Where the loop changes direction, the saw cuts shall be overlapped to provide full depth at all corners. No dry cutting of the pavement will be permitted. Each loop shall have its own drilled curb hole with 1-inch conduit installed from J-box or service box to within 1/2-inch of bottom of saw cut. This conduit shall be grey smooth wall liquidtight flexible non-metallic type "LFNC" approved for direct burial and meeting UL listing file #E79553.

Before installing the loop wire, the saw cuts shall be checked and any jagged edges or protrusions shall be removed. The slots must be cleaned and dried to remove cutting dust, grit, oil, moisture, or other contaminants. Cleaning shall be achieved by flushing the slot with a high pressure water jet system. The slots shall then be cleared of water and dried using oil-free compressed air.

Each loop shall be coiled according to the plans and the beginning conductor banded in the terminating hand hole or base with a symbol "S" to denote start of conductor. Each loop shall be further identified by phase or function, as shown on the plans, with durable waterproof nylon cable marker flagstraps. Color tape banding will not be allowed for this purpose.

Loop conductor shall be installed using a wood paddle. If the wire does not lay on the bottom of the saw cut, it shall be held down using a material such as backer rod.

Each loop shall be tested with an approved loop tester capable of measuring both effective inductance of an inductive roadway loop and the operating frequency of a single channel loop detector, before the loop is sealed. The tester shall have an inductance range between 50 and 700 microhenrys with a frequency range between 25 and 100 kilohertz. The tester shall be accurate to within 3%. This measurement shall be logged and become a part of the AS BUILT plans. Each loop shall also be tested for operation through the detector amplifier before the loop is sealed.

Each loop curb-hole end shall be sealed with electrical duct seal prior to sealing loop.

Each loop shall immediately be sealed to within 1/8-inch of top of saw cut with a one-part, moisture-curing, self-leveling, polyurethane sealer manufactured for this purpose and applied in accordance with the manufacturer's recommendations, unless otherwise approved by the city traffic engineer.

N. **GROUNDING:** All traffic signal poles, pedestals, controller cabinets, and power sources, shall be grounded using individual ground rods. All ground wires shall be attached using a ground clamp to a copperweld rod unless otherwise shown on the plans. The ground rod shall have a 3/4-inch diameter and a minimum length of 10 feet. Grounding will be accomplished by the most direct, straightest, and shortest route from ground rod to grounding terminal. A green #6 THHN stranded copper shall bond the entire intersection. Splices will be permitted in service boxes using appropriate grounding lugs for the purpose of common bonding.

SECTION 4: INTERSECTION INSPECTION

Upon completion, the contractor shall notify the city traffic engineer. At a future time designated by the city traffic engineer, the contractor shall open all pull boxes, pole bases, pedestal bases, service boxes, and control box for inspection by City personnel. Any discrepancies shall be noted on a "punch list" and shall be corrected prior to Final Inspection. A Final Inspection shall be conducted before the intersection will be accepted by the City of Lawrence as complete.

Upon completion of inspection and acceptance by the City of Lawrence, but prior to final payment, the contractor shall furnish the city traffic engineer with "as-built" plans "to scale". The plans shall include any modifications, changes, and variations, different from the original project plans. In addition, the contractor shall furnish the city traffic engineer a minimum of two (2) field wiring diagrams of each cabinet.