S-800 TRAFFIC SIGNALS: This work shall include the furnishing of all labor, materials and equipment for the installation of a complete operational traffic signal installation in accordance with the plans and these Specifications. A complete list of pre-approved traffic signal materials is available at the office of the City Engineer or can be found on the City of Lenexa's website at ***www.lenexa.com***.

A. MATERIALS AND EQUIPMENT: Unless otherwise noted in the plans, all equipment, materials and incidental parts shall be new and of similar manufacturer. All incidental parts which are not shown on the plans or described in these Specifications and which are necessary to complete the traffic signal installation, shall be furnished and installed as though such parts were shown on the plans or described in these Specifications. The cost shall be included in the traffic signal installation lump sum bid price.

1. All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA). In addition to the requirement of these Specifications, all material shall conform to the requirements of the National Electrical Code (NEC), the Standards of the American Society of Testing Materials (ASTM), the American Standards Association (ASA) and local ordinances.
2. All concrete supplied for the work shall be Class JCCB-4K and conforming to the section of these Specifications entitled "Concrete Construction".
3. All reinforcing steel shall meet the requirements of steel bars for concrete reinforcement in the section of this specification titled "Reinforcing Steel".
4. Traffic Signal Poles shall conform to these Specifications, the plans and the 2009 edition of AASHTO's Standard Specifications for Structural Supports for Signs, Luminaires and Traffic Signals. The pole and arm shall be a round, tapered monotube made only of one length of the best grade, structural steel sheet of not less than 7 Manufacturing Standard Gauge. Only one longitudinal weld and no transverse welds shall be permitted in the fabrication of the shaft or arm. The steel anchor base of adequate strength, shape and size shall be secured to the lower end of the shaft by welding in such manner as to develop the full strength of the adjacent shaft section to resist bending action. The steel poles shall be galvanized to ASTM A-123 standards. All accessories shall be galvanized to ASTM A-153 standards. The tapered steel shaft shall include high strength anchor bolts and nuts that meet the following requirements:

Tensile Strength (minimum)		75,000 psi
Yield Strength at 0.2% offset (minimum)		55,000 psi
Elongation:	8" min.	18%
	2" min.	21%

5. The anchor bolts shall be hot dipped galvanized on the threaded end after threading. The galvanizing shall include all threads and not less than six inches of the adjacent unthreaded portion of the bolts. Anchor bolts shall be threaded to a length shown on the plans or in the Standard Details. Threads shall be Coarse Thread Series as specified in ANSI B1.1 and may be formed by cutting or rolling. Nuts for anchor bolts shall be Heavy Hex leveling nuts and Heavy Hex nuts as specified in ANSI B18.2.2. Nuts shall comply with the proof load or Brinell hardness requirements of ASTM A307. After galvanizing, the thread fit of the bolt-nut combination shall be snug and shall be such that the nuts can be turned on the bolts without the application of excessive torque. The Engineer may conduct proof load tests on the bolt-nut combination to check the thread fit.

6. The pole shaft shall also include a hand hole and cover, cast pole top, a J-hook wire support, and a suitable bolt-on type device for attaching the mast arm to the shaft as shown on the Traffic Signal Detail sheets in the accompanying plans. The tapered steel arm shall include a removable end cap.
7. Where a combination lighting/signal pole is specified on the plans, the above applies with the luminaire arm to be mounted in the same vertical plane as the signal arm (except where otherwise noted on the plans). The vertical shaft of the combination lighting/signal pole shall be a one-piece design and shall contain an additional hand hole located 4 inches above the mast arm on the opposite side of the pole from the mast arm. See Detail 2 on the Traffic Signal Structures standard detail sheet for more information.
8. When fully loaded with all equipment as shown on the plans, all mast arms shall be between horizontal (level) to one and one-half degrees (1-1/2°) above horizontal. No perceptible bending of the arm shall be observed when fully loaded, as determined by a visual inspection by the Engineer.
9. All traffic signal poles shall be detailed on shop drawings by the manufacturer indicating pole and arm dimensions and attachment method along with signal weight, projected areas, and type of mounting that it is designed to accommodate.
10. Aluminum pedestals shall consist of aluminum, die cast or sand cast square base and a 4” diameter shaft for mounting vertical signal heads or a standard controller cabinet. The pedestal shall be capable of withstanding wind loadings of 100 mph.
11. The cast aluminum bases shall meet the requirements of ASTM B108 Alloy 356-T6, ASTM B-26, SG70A-T6, S5A.F, or ASTM B-108, SG70A-T6. The base and post shall be joined by welded connections. The aluminum shaft shall be spun from one piece of seamless tubing, meeting the requirements of ASTM Alloy 6063-T6 and having a minimum nominal 0.125” wall thickness. The shaft shall have no longitudinal welds, nor circumferential welds. The shaft shall have a uniform polished finish. Each shaft shall be tire-wrapped with a heavy water-resistant paper for protection during shipment and installation.
12. Each vehicle signal head shall be a weather tight assembly of one or more signal faces of the sizes shown on the plans. All brackets and fittings necessary for proper mounting with the type of signal support designated on the plans shall be furnished. Banding for signal heads shall be 3/4” stainless steel. Each signal face shall consist of one or more signal sections, rigidly and securely fastened together, capable of being positively positioned to control the movement of one direction of traffic. Each signal section shall be a self-contained assembly consisting of an optical unit with housing, housing door, and visor. Tie rods shall not be used to fasten signal sections together to form a signal face. All signal heads on a project shall be the product of one manufacturer and shall be a single model number for like items. For signal modification projects, new signal heads shall match existing signal heads with respect to manufacturer and model. Terminal blocks of suitable size shall be placed in the middle section of the signal head.
13. The housing for each signal section shall be made of a durable polycarbonate and shall be yellow in color. It shall be clean, smooth and free from flaws, cracks, blowholes, and other imperfections. It shall be designed as a self-contained unit capable of separate mounting or inclusion in a signal face containing two or more signal sections rigidly and securely fastened together. It shall be equipped with round openings in the top and bottom so that it may be

rotated between waterproof supporting brackets and thus be capable of being directed at any angle in the horizontal plane. It shall be equipped with positive locking devices to maintain a specific angle of direction when in place. The doors shall be black in color and consist of polycarbonate construction. They shall be suitably hinged and held securely to the body of the housing by simple stainless steel locking devices. All other door parts, such as hinge pins, lens clips, screws, etc., shall also be of stainless steel material.

14. The visors for each signal section shall be durable polycarbonate, black in color, not less than 0.05 inches in thickness and shall be tunnel-type. It shall be designed to fit tightly against the door, and shall not permit any perceptible filtration of light between it and the housing door. Visors shall be at least 9.5 inches long for 12" diameter signals and shall angle slightly downward.
15. The optical unit and visor shall be designed as a whole so as to eliminate the return of outside rays entering the unit from above the horizontal.
16. Lenses shall meet the requirements of ANSI D-10.1-1966 optical specifications and shall be glass for incandescent style. Lettering shall not appear on lenses. Nominal 12" diameter signal lenses shall be furnished, unless otherwise shown on the accompanying plans.
17. All traffic signal indications for new signal installations as well as signal modification projects shall be LED displays. LED indications shall be 12" diameter, 120-volt LED's in a self-contained enclosure with a 10-year life expectancy. LED indications shall comply with the latest edition of ITE's Interim Purchase Specification – Vehicle Traffic Signal Control Heads, Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules.
18. The construction materials and colors for pedestrian signal heads shall conform to those listed in the previous section with the following additions outlined below. The LED module shall display a solid Portland orange hand and lunar white man and two Portland orange countdown numbers. Pedestrian symbols shall be a minimum of 9 inches high for 12" lenses. LED indications shall comply with the latest edition of ITE's Interim Purchase Specification – Vehicle Traffic Signal Control Heads, Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules. The legends shall conform to the ITE Specification Pedestrian Traffic Control Signal Indications. All lenses shall be 12 inches unless indicated otherwise in the accompanying plans.
19. The pedestrian signal door and visor shall be black in color. All 12" pedestrian signals shall have 9" to 9.75" tunnel visors. All visors shall be a minimum of 0.06 inches thick.
20. The pedestrian and countdown indications shall be 120-volt LEDs in self-contained enclosures and shall have a 10-year life expectancy.
21. Vertical bracket mounted signal heads, as shown on the plans, shall be supported by a one-piece mounting bracket watertight assembly made entirely of a durable polycarbonate and be yellow in color. Each bracket shall be either plumb or level, symmetrically arranged and securely assembled. Each bracket shall have serrations for positioning traffic signals in increments of 5^{o}. Construction shall be such that conductors are concealed within the assembly. Brackets shall be attached to the pole or pedestal by approved stainless steel banding and brackets.
22. Mast arm signal head assemblies shall be rigid mounted utilizing a universally adjustable bracket consisting of both top and bottom brackets with a center vertical extruded aluminum support tube attached to the mast arm by means of a clamp kit with stainless steel cable. The vertical support tube shall allow wire

entry at any point and be equipped with a vinyl insert that conceals the wiring. The lower bracket arm shall be accessible for wiring entry into the signal head.

23. Where shown on the plans, 5” one-piece back plates shall be furnished and attached to the signal section to provide a dark background for signal indications. Back plates shall be attached to the signals as per the manufacturer's recommended practice.
24. Pedestrian push buttons shall be audible and shall be direct-push, contact-type with a bull-dog style. Each push button shall be a removable contact assembly mounted in a durable yellow case. Contacts shall be normally open, entirely insulated from the case and operating button, and have connecting terminals. The operating button shall be brass or another corrosion resistant metal alloy and shall be sturdy. The operating voltage shall not exceed 18 volts. The entire assembly shall be weatherproof, vandal-resistant**,** secure against electrical shock to the user, and of such construction as to withstand hard usage. The pedestrian push button shall be mounted directly to the pole in a watertight assembly and shall be the large button type meeting ADA requirements. If the reach for the pedestrian buttons exceeds 10 inches, the contractor shall use a pushbutton extender.
25. Multi-conductor signal cable shall conform to Specification 19-1 of the latest edition of the International Municipal Signal Association, Inc. (IMSA) requirements, except all conductors supplied shall be stranded copper with a minimum size of No. 14 AWG. The number and size of conductors per cable shall be as shown on the plans.
26. The detector loop wire shall be No. 14 AWG, stranded copper, conforming to IMSA Specification 51-5 (Single conductor PVC/Nylon with tube jacket).
27. Sealant for loop detectors shall be prepared and installed in accordance with the manufacturer's instructions. The Contractor shall submit the manufacturer's instructions to the Engineer for review and approval. Regardless of the manufacturer’s instructions, the sealant shall be squeegeed into the saw cuts. All curb cuts shall be sealed with duct seal.
28. The detector lead-in cable shall be No. 18 AWG 4-conductor, stranded and shielded cable. The conductor and drain wires shall be tinned copper wires with conductors shielded by a layer of aluminized polyester. All wires shall be insulated with cross-linked polypropylene or polyethylene and provided with a vinyl jacket.
29. Power lead-in cable shall be of the sizes and number of conductors as shown on the plans. The power lead-in cable shall be for operation on a 600 volt maximum and suitable for use at conductor temperatures not exceeding 75° C. Material, construction, and tests shall be in accordance with the applicable requirements of the IPCEA Standard S-66-524 "Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy".
30. This item shall govern the above ground radar presence detector (RPD) equivalent to the Wavetronix SmartSensor Matrix. The RPD shall present real-time presence data in 10 lanes. The RPD shall support a maximum of eight zones and shall support four channels and have user-selectable channel assignments. The RPD shall use OR logic to combine multiple zones to a channel output, and shall have channel output extend and delay functionality. The RPD algorithms shall mitigate detections from wrong way or cross traffic. The RPD system shall have fail-safe mode capabilities for contact closure outputs if communication is lost. With regards to detection area and range, the

RPD shall be able to detect and report presence in lanes with boundaries as close as 6 ft. from the base of the pole on which the RPD is mounted. The RPD shall be able to detect and report presence in lanes located within the 100-foot arc from the base of the pole on which the RPD is mounted. The RPD shall be able to detect and report presence for vehicles within a 90 degree field of view. The RPD shall be able to detect and report presence in up to 10 lanes and shall be able to detect and report presence in curved lanes and areas with islands and medians. For each approach to be detected, one RPD corner radar shall be used.

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

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

The preassembled back plate for the RPD shall be a cabinet side mount or rack mount. The RPD shall use contact closure input file cards with 2 or 4 channel capabilities. The contact closure input file cards for the RPD shall be compatible with industry standard detector racks.

The RPD shall not require cleaning or adjustment to maintain performance. The RPD shall not rely on battery backup to store configuration information, thus eliminating any need for battery replacement. Once the RPD is calibrated, it shall not require recalibration to maintain performance unless the roadway configuration changes.

The RPD shall not exceed 4.2 lbs. in weight and shall not exceed 13.2 inches by 10.6 inches by 3.3 inches in its physical dimensions. All external parts of the RPD shall be ultraviolet-resistant, corrosion-resistant, and protected from fungus growth and moisture deterioration. The RPD shall be enclosed in a Lexan EXL polycarbonate. The enclosure shall be classified “f1” outdoor weather ability in accordance with UL 746C. The RPD shall be classified as watertight according to the NEMA 250 Standard. The RPD enclosure shall conform to test criteria set forth in the NEMA 250 standard for type 4X enclosures. Test results shall be provided for each of the following type 4X criteria:

- External Icing (NEMA 250 clause 5.6)
- Hose-down (NEMA 250 clause 5.7)
- 4X Corrosion Protection (NEMA 250 clause 5.10)
- Gasket (NEMA 250 clause 5.14)

The RPD shall be able to withstand a drop of up to 5 ft. without compromising its functional and structural integrity. The RPD enclosure shall include a connector that meets the MIL-C-26482 specification. The MIL-C-26482 connector shall provide contacts for all data and power connections. The RPD shall consume less than 10 W. The RPD shall operate with a DC input between 9 VDC and 28 VDC. The RPD shall have two communication ports, and both ports shall

communicate independently and simultaneously. Two independent communication ports allow one port to be used for configuration, verification and traffic monitoring without interrupting communications on the dedicated data port. The RPD shall support the upload of new firmware into the RPD's non-volatile memory over either communication port. The RPD shall support the user configuration of the following:

- Response delay
- Push port

The communication ports shall support a 9600 bps baud rate. The RPD shall be designed with a matrix of radars. The matrix of radars enables the sensor to provide detection over a large area and to discriminate lanes. The circuitry shall be void of any manual tuning elements that could lead to human error and degraded performance over time.

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

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

The RPD shall not rely on temperature compensation circuitry to maintain transmit frequency stability. Temperature-based compensation techniques have been shown to be insufficient to ensure transmit frequency stability. One reason this type of technique is not sufficient is that it does not compensate for frequency variations due to component aging.

The bandwidth of the transmit signal of the RPD shall not vary by more than 1% under all specified operating conditions and over the expected life of the RPD. The bandwidth of an RPD directly affects the measured range of a vehicle. A change in bandwidth causes a direct error in the measured range, i.e., a 5% change in bandwidth would cause a range error of 10 ft. for a vehicle at 200 ft. If the bandwidth changes by more than 1% due to seasonal temperature variations and component aging, then the RPD will need to be frequently reconfigured to maintain the specified accuracy.

The RPD antennas shall be designed on printed circuit boards. Printed circuit board antennas eliminate the need for RF connectors and cabling that result in decreased reliability. Printed circuit antennas are less prone to physical damage due to their extremely low mass. The vertical beam width of the RPD at the 6dB

points of the two-way pattern shall be 65 degrees or greater. The antennas shall cover a 90 degree horizontal field of view. The sidelobes in the RPD two-way antenna pattern shall be -40dB or less. Low sidelobes ensure that the performance from the antenna beam widths is fully achieved.

The RPD shall transmit a signal with a bandwidth of at least 245 MHz. The bandwidth of the transmit signal translates directly into radar resolution, which contributes directly to detection performance. For example, an RPD that transmits at a low bandwidth will have low radar resolution, which could cause it to count a single vehicle as two vehicles in adjacent lanes. As another example of the adverse effects of low radar resolution, the response from a sign or other radar target in the roadway may spill over into the lanes of travel and desensitize the radar. In order to achieve the specified detection accuracy in a variety of conditions, the unwindowed radar resolution cannot be larger than 2 ft. (0.6 m) at the half-power level, which requires a bandwidth of 240 MHz. The high radar resolution reduces the problem of vehicle responses getting drowned out by brighter vehicles in adjacent lanes and improves performance for moving and stopped vehicles near roadway targets. The RPD shall provide at least 8 RF channels so that multiple units can be mounted in the same vicinity without causing interference between them.

The RPD shall have a self-test that is used to verify correct hardware functionality. The RPD shall have a diagnostics mode to verify correct system functionality. The RPD shall have a method for automatically defining traffic lanes, stop bars and zones without requiring user intervention. This auto-configuration process shall execute on a processor internal to the RPD and shall not require an external PC or other processor. The auto-configuration process shall work under normal intersection operation and may require several cycles to complete. The auto-configuration method shall not prohibit the ability of the user to manually adjust the RPD configuration. The RPD shall support the configuring of lanes, stop bars and detection zones in 1-ft. increments. When lanes have variable widths or have variable spacing (e.g. gore between lanes), precise resolution is necessary.

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

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

The RPD shall maintain accurate performance in all weather conditions, including rain, freezing rain, snow, wind, dust, fog and changes in temperature and light, including direct light on sensor at dawn and dusk. RPD operation shall continue in snow or in rain up to 1 in. per hour. The RPD shall be capable of continuous operation over an ambient temperature range of -40°F to 165.2°F (-40°C to 74°C). The RPD shall be capable of continuous operation over a relative humidity range of 5% to 95% (noncondensing).

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

The RPD shall comply with the applicable standards stated in the NEMA TS2-2003 Standard. Third party test results shall be made available for each of the following tests:

- Shock pulses of 10g, 10 ms half sine wave
- Vibration of 0.5 Grms up to 30 Hz
- 300 V positive/negative pulses applied at one pulse per second at minimum and maximum DC supply voltage

Cold temperature storage at -49°F (-45°C) for 24 hours

- High temperature storage at 185°F (85°C) for 24 hours
- Low temp, low DC supply voltage at -29.2°F (-34°C) and 10.8 VDC
- Low temp, high DC supply voltage at -29.2°F (-34°C) and 26.5 VDC
- High temp, high DC supply voltage at 165.2°F (74°C) and 26.5 VDC
- High temp, low DC supply voltage at 165.2°F (74°C) and 10.8 VDC

The RPD shall be manufactured and assembled in the U.S.A. The internal electronics of the RPD shall utilize automation for surface mount assembly, and shall comply with the requirements set forth in IPC-A-610C Class 2, Acceptability of Electronic Assemblies. The RPD shall undergo a rigorous sequence of operational testing to ensure product functionality and reliability. Testing shall include the following:

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

Test results and all associated data for the above testing shall be provided for each purchased RPD by serial number, upon request. The RPD manufacturer shall provide both training and technical support services. The manufacturer-provided training shall be sufficient to fully train installers and operators in the installation, configuration, and use of the RPD to ensure accurate RPD performance. The manufacturer-provided training shall consist of comprehensive classroom labs and hands-on, in-the-field, installation and configuration training. Classroom lab training shall involve presentations outlining and defining the

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

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

Field training shall provide each trainee with the hands-on opportunity to install and configure the RPD at roadside. Training shall be such that each trainee will mount and align the RPD correctly. Manufacturer-provided technical support shall be available according to contractual agreements, and a technical representative shall be available to assist with the physical installation, alignment, and auto-configuration of each supplied RPD. Technical support shall be provided thereafter to assist with troubleshooting, maintenance, or replacement of RPDs should such services be required. RPD documentation shall include an instructional training guide and a comprehensive user guide as well as an installer quick-reference guide and a user quick-reference guide. The RPD manufacturer shall supply the following documentation and test results at the time of the bid submittal:

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

The RPD shall be warranted free from material and workmanship defects for a period of two years from date of shipment. The RPD shall be mounted directly onto a mounting assembly fastened to a mast arm, pole or other solid structure. The RPD mounting assembly shall provide the necessary degrees of rotation to ensure proper installation. The RPD mounting assembly shall be constructed of weather-resistant materials and shall be able to support a 20-lb. load. The RPD shall be mounted at a height that is within the manufacturer's recommended mounting heights. The RPD shall be mounted at an offset from the first lane that is consistent with the RPD's minimum offset. The RPD shall be mounted so that at least 20 feet along the farthest lane to be monitored is within the field view of the RPD. The RPD shall be mounted with its cable connector down and shall be tilted so that the RPD is aimed at the center of the lanes to be monitored. Typically, the RPD is tilted off of vertical by 20–30 degrees. The RPD shall be mounted on a vertical signal pole or on the horizontal mast arm. The RPD shall be mounted so that its field of view is not occluded by poles, signs or other structures. RPDs that are mounted within 20 ft. of each other or that are monitoring the same intersection shall be configured to operate on different RF

channels regardless of the pointing direction of the RPDs. It is recommended that the manufacturer be consulted to verify final RPD placement if the RPD is to be mounted near large planar surfaces (sound barrier, building, parked vehicles, etc.) that run parallel to the monitored roadway.

The cable end connector shall meet the MIL-C-26482 specification and shall be designed to interface with the appropriate MIL-C-26482 connector. The connector backshell shall be an environmentally sealed shell that offers excellent immersion capability. All conductors that interface with the connector shall be encased in a single jacket, and the outer diameter of this jacket shall be within the backshell's cable O.D. range to ensure proper sealing. The backshell shall have a strain relief with enough strength to support the cable slack under extreme weather conditions. Recommended connectors are Cannon's KPT series, and recommended backshells are Glenair Series 37 cable sealing backshells. The cable shall be the Orion Wire Combo-2204-2002-PVCGY or an equivalent cable that conforms to the following specifications:

- The RS-485 conductors shall be a twisted pair.
- The RS-485 conductors shall have nominal capacitance conductor to conductor of less than 71pF/Ft at 1 Khz.
- The RS-485 conductors shall have nominal conductor DC resistance of less than 16.5 ohms at 68°F (20°C).
- The power conductors shall be one twisted pair with nominal conductor DC resistance of less than 11.5 ohms at 68°F (20°C).
- Each wire bundle or the entire cable shall be shielded with an aluminum/mylar shield with a drain wire.

The cable shall be terminated only on the two farthest ends of the cable. The cable length shall not exceed 2000 ft for the operational baud rate of RS-485 communications. If 12 VDC is being supplied for the RPD then the cable length shall not exceed 110 ft. If 24 VDC is being supplied for the RPD then the cable length shall not exceed 600 ft. Both communication and power conductors can be bundled together in the same cable as long as the above-mentioned conditions are met.

The RPD shall be installed using the SmartSensor Matrix Preassembled Traffic Cabinet Backplate or an equivalent that provides input power surge suppression, sensor cable surge suppression, AC to DC power conversion (if necessary), and terminal blocks. The surge protection devices shall meet or exceed the EN 61000-4-5 Class 4 specifications. If needed, the RPD shall be installed using the Click! 202, Click! 204 or an equivalent AC to DC power converter that meets the following specifications:

- The power converter shall be power rated at 48 W for temperatures less than 140°F (60°C) with a 5% power decrease for each degree increase up to 158°F (70°C).
- The power converter shall operate in the temperature range of to -29.2°F to +165.2°F (–34°C to +74°C).
- The power converter shall operate in the humidity range of 5% to 95% at 77°F (25°C) non-condensing.

- The power converter shall accept an input voltage of 85 VAC to 264 VAC or 120 VDC to 370 VDC.
- The power converter shall operate at an input frequency of 47 Hz to 63 Hz.
- The power converter shall produce an output voltage of 24 VDC ±4%.
- The power converter shall withstand a voltage across its input and output of 2 kV. The power converter shall withstand a voltage across its input and ground of 1.5 kV.
- The power converter shall conform to safety standards UL 60950 and EN60950.
- The power converter shall conform to EMC standards EN55022 Class B and EN61000-3-2, 3.

In brown-out conditions (i.e. <85VAC input), the output voltage of the power converter shall be less than 1 VDC. The terminal blocks shall be color-coded insulation displacement terminal blocks. The terminal blocks shall be prewired to the other in-cabinet equipment so that no wiring other than cable terminations, connecting input power and connecting input file cards shall be required during installation.

The Click! 114, Click! 112 or an equivalent that meets the following specifications shall be used. The input file cards shall be compatible with 170, 2070, NEMA TS1, and NEMA TS2 style input racks. The input file card shall translate data packets from the RPD into contact closure outputs. The input file card shall support presence detection. The input file card shall receive data packets over an RS-485 bus at a baud rate of 9600 bps. The input file card shall autobaud and auto-detect an RPD over wired and wireless communication channels that have a maximum latency of 500 ms. The input file card shall comply with the NEMA TS2-1998 Traffic Controller Assemblies with NTCIP Requirements (Section 2.8 specification).

31. This item shall govern the above-ground continuous tracking advance detector (CTAD) equivalent to the Wavetronix SmartSensor Advance™. The CTAD shall detect range, speed, vehicle estimated time of arrival (ETA) to the stop bar for vehicles or clusters of vehicles moving in the user-selected direction of travel. The CTAD shall also detect instantaneous roadway efficiency. The CTAD shall be able to simultaneously detect and report information from up to 25 vehicles on the roadway when they are serially sequenced between the near and far boundaries. The CTAD shall turn on a zone output when the range, speed, ETA, and qualified count or instantaneous roadway efficiency requirements for that zone are satisfied. The CTAD shall turn on an alert output on when the user-defined zone output combinational logical is satisfied. The CTAD shall turn on a normal channel output when any of the channel's alerts is on and the channel's delay and extend time constraints are satisfied. The CTAD shall turn on a latched channel output when the on alert is turned on and the delay time is satisfied. The CTAD shall turn off a latched channel output when the off alert is turned on or the max timer expires and the extension time is satisfied. Channel outputs are used to create contact closures which can be used as inputs into a traffic controller. The CTAD shall provide vehicle call and extend data on up to eight channels that can be connected to contact closure modules compliant with

NEMA TS 1, NEMA TS 2, 170, and 2070 controller cabinets. The CTAD shall be capable of providing data for each tracked detection over the serial ports. When vehicular track file data is available on the serial ports, the data is then available on the communications network without the use of a traffic controller or a contact closure data recorder. Vehicular track file data is useful for traffic study applications and for performing comparisons between traffic sensors.

The CTAD shall be able to detect and report vehicle information when mounted within 50 ft. of the center of the lanes of interest. The CTAD shall be able to detect and report vehicle information when mounted at heights up to 40 ft. above the road surface. The CTAD shall be able to detect and report information on the roadway located with the near boundary at 50 ft. from the base of the pole on which the CTAD is mounted. The CTAD shall be able to detect and report information on the roadway located with the far boundary at 500 ft. from the base of the pole on which the CTAD is mounted. For incoming traffic, 95 percent of large vehicles within the line-of-site of the CTAD shall be detected and reported before they arrive 400 ft. from the sensor. For incoming traffic, 90 percent of all motor vehicles within the line-of-site of the CTAD shall be detected and reported before they arrive 400 ft. from the sensor. The CTAD shall detect at least 98 percent of large vehicles like truck-trailer combinations and at least 95 percent of all motor vehicles within the line-of-sight of the CTAD sensor where multiple detections of multi-unit vehicles are not considered false detections and merged detections of adjacent lane vehicles are not considered missed detections.

The CTAD shall provide range measurements in which 90% of the measurements are accurate within 10 ft. when the vehicle is tracked independently. The CTAD shall provide per vehicle speed measurements in which 90% of the measurements are accurate within 5 mph when tracked independently. The CTAD shall provide estimated time-of-arrival (ETA) measurements in which 85% of the measurements are accurate within one second, when the detected vehicles are tracked independently at a constant speed above 40 mph and are within 2.5 and 5.5 seconds of the stop bar.

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

The CTAD shall not exceed 4 lbs. in weight. The CTAD shall not exceed 14 inches × 11 inches × 4 inches in its physical dimensions. All external parts of the CTAD shall be ultraviolet-resistant, corrosion-resistant, and protected from fungus growth and moisture deterioration. The CTAD shall be enclosed in a Lexan polycarbonate. The enclosure shall be classified “f1” outdoor weatherability in accordance with UL 746C. The CTAD shall be classified as watertight according to the NEMA 250 standard.

The CTAD enclosure shall conform to test criteria set forth in the NEMA 250 standard for type 4X enclosures. Test results shall be provided for each of the following type 4X criteria:

- External icing (NEMA 250 clause 5.6)
- Hose-down (NEMA 250 clause 5.7)
- 4X corrosion protection (NEMA 250 clause 5.10)
- Gasket (NEMA 250 clause 5.14)

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

The CTAD shall consume less than 4 W @ 12 VDC. The CTAD shall operate with a DC input between 12 VDC and 28 VDC. The CTAD shall have onboard surge protection. The CTAD shall have two communication ports, and both ports shall communicate independently and simultaneously. Two independent communication ports allow one port to be used for configuration, verification and traffic monitoring without interrupting communications on the dedicated data port. The CTAD shall support the upload of new firmware into the CTAD's non-volatile memory over either communication port. The CTAD shall support the user configuration of the following:

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

Both communication ports shall support all of the following baud rates: 9600, 19200, 38400, 57600 and 115200 bps. The contact closure output frequency shall be user configurable as short as 10 ms, with a default near 130 ms for compatibility. Contact closure data shall be reliably communicated over homerun cable connections as long as 600 ft. with latency from the time of channel requirement satisfaction to the eventual reporting of the detections on the back edge of the contact closure card in 15 ms or less. Contact closure data latency is dependent on baud rate and output frequency settings. The required minimum must be achievable when the baud rate is set to a high value and the output frequency is set to a frequent value.

The circuitry shall be void of any manual tuning elements that could lead to human error and degraded performance over time. All transmit modulated signals shall be generated by means of digital circuitry, such as a direct digital synthesizer, that is referenced to a frequency source that is at least 50 parts per million (ppm) stable over the specified temperature range, and ages less than 6 ppm per year. Any upconversion of a digitally generated modulated signal shall preserve the phase stability and frequency stability inherent in the digitally generated signal. This specification ensures that, during operation, the CTAD strictly conforms to FCC requirements and that the radar signal quality is maintained for precise algorithmic quality. Analog and microwave components within a CTAD have characteristics that change with temperature variations and age. If the output transmit signal is not referenced to a stable frequency source, then the CTAD is likely to experience unacceptable frequency variations which may cause it to transmit out of its FCC allocated band and thus will be non-compliant with FCC regulations. The CTAD shall not rely on temperature

compensation circuitry to maintain transmit frequency stability. Temperature-based compensation techniques have been shown to be insufficient to ensure transmit frequency stability. One reason this type of technique is not sufficient is that it does not compensate for frequency variations due to component aging. The bandwidth of the transmit signal of the CTAD shall not vary by more than 1% under all specified operating conditions and over the expected life of the CTAD. The bandwidth of a CTAD directly affects the measured range of a vehicle. A change in bandwidth causes a direct error in the measured range, i.e., a 5% change in bandwidth would cause a range error of 10 ft. for a vehicle at 200 ft. If the bandwidth changes by more than 1% due to seasonal temperature variations and component aging, then the CTAD will need to be frequently reconfigured to maintain the specified accuracy.

The CTAD antennas shall be designed on printed circuit boards. Printed circuit board antennas eliminate the need for RF connectors and cabling that result in decreased reliability. Printed circuit antennas are less prone to physical damage due to their extremely low mass. The vertical beam width of the CTAD at the 6 dB points of the two-way pattern shall be 65 degrees or greater. This enables the CTAD to provide simultaneous detection from the nearest to the farthest ranges. The vertical beam width of a CTAD determines the field of view in which it can detect traffic. The horizontal beam width of the CTAD at the 6 dB points of the two-way pattern shall be 11 degrees or less. A narrow horizontal beam width narrows the field of view of the CTAD to the lanes of interest and helps to exclude the traffic traveling in the opposite direction. The sidelobes in the CTAD two-way antenna pattern shall be -40 dB or less. Low sidelobes ensure that the performance from the antenna beam widths is fully achieved.

The CTAD shall provide at least four RF channels so that multiple units can be mounted in the same vicinity without causing interference between them. The CTAD shall have a method for automatically configuring the sensitivity of detection in at least 5-ft. increments. This allows the sensor to quickly and accurately record the intensity of roadside clutter and set appropriate rejection thresholds to avoid false detections at different ranges. The auto-configuration method shall not prohibit the ability of the user to manually adjust the CTAD configuration. The CTAD shall support the configuration of up to eight channel outputs with up to four alerts per channel and up to four zones per alert, resulting in 32 configurable alerts and 128 configurable zones.

The CTAD shall support the configuring of zones in 5-ft. increments. The CTAD shall support detection zones as long as 450 ft. The ability to define one large zone simplifies and enhances configuration when compared to point detection schemes. The CTAD shall support user configurable high-speed and low-speed detection filters for each zone. The CTAD shall support the configuring of speed filters in 1-mph increments. The speed thresholds can be used to provide superior gap management for green extension applications at signalized intersections, especially when a high-speed traffic stream presents a limited number of opportunities to gap out. For example, when the operational objective is to increase safety by extending the green light for law-abiding high-speed drivers, reporting of low-speed vehicles is not desirable. On the other hand, when the operational objective is to increase efficiency by extending the green light for clearance of a low-speed traffic queue, reporting of high-speed vehicles is not

desirable. In addition, these speed filters can be configured to screen outreporting of detections that may adversely impact operational objectives. For example, low speed filters can also be used to screen out detection of low-speed clutter like unwanted detection of turn-only bays, pedestrians, swaying trees, and vibrating signs. The CTAD shall support user configurable upper and lower estimated time-of-arrival (ETA) filters for each zone. The CTAD shall support the configuring of ETA filters in increments of 0.1 seconds. The ETA thresholds can be used to provide superior gap management for green extension applications at signalized intersections, especially when a high-speed traffic stream presents a limited number of opportunities to gap out. For example, when the operational objective is to increase safety by extending the green light for law-abiding high-speed drivers, reporting of vehicles upstream of 5.5 seconds and downstream of 2.5 seconds may not be desirable. Vehicles with 2.5 to 5.5 seconds are commonly considered to be in the driver dilemma zone when the light turns yellow. However, motorists closer than 2.5 seconds can easily clear the intersection and those beyond 5.5 seconds can be expected to stop. Dilemma zone protection has been shown to reduce red-light running and rear-end collisions. ETA filtering provides a dynamic form of dilemma zone protection that adapts when traffic speeds rise above or fall below design assumptions used with traditional methods of fixed-point detection. ETA filtering also constrains reporting of detections to provide more gap out opportunities, avoid the likelihood of reaching maximum green, and maximize the effective use of green by timing clearance of the last vehicle. Therefore, ETA filtering also provides practical efficiency benefits. The CTAD shall provide configurable upper and lower count filters that help determine if a required number of qualified detections are present. The CTAD shall support the configuring of qualified count filters in increments of one. These filters can be to provide superior gap management for green extension applications at signalized intersections, especially when a high-speed traffic stream presents a limited number of opportunities to gap out. Qualified count is tied to the number of vehicles that meet the range, speed and ETA requirements of a zone. For example, for green extension it may be required that there are two vehicles detected within 2.5 to 5.5 seconds of the stop bar traveling above 35 mph (56 kph), instead of just one. The logic is that if only one vehicle is in the dilemma zone, this is not as threatening as if there are two vehicles (one following the other). The following vehicle may incorrectly assume that the lead vehicle will try to clear the intersection and cause a rear-end collision. Rear-end collisions are the most common form of collision at a signalized intersection.

The CTAD shall include graphical user interface software that displays the current traffic pattern using a graphical traffic representation. A visual representation of traffic patterns allows an installer to quickly associate specific detections with corresponding vehicles, and it facilitates verification of CTAD performance. The graphical user interface shall also display all configured alerts and provide visual representation of their actuation. The graphical user interface shall provide a means of logging the vehicular track files with an update rate of greater than five times per second.

The user configured baud rate will affect the rate at which log files are logged. This requirement must be met at higher baud rates. The graphical interface shall

operate on Windows Mobile, Windows XP, Windows Vista, and Windows 7 in the .NET framework. The software shall support the following functionality:

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

The CTAD shall maintain accurate performance in all weather conditions, including rain, freezing rain, snow, wind, dust, fog and changes in temperature and light, including direct light on sensor at dawn and dusk. CTAD operation shall continue in rain up to 4 in. per hour. The CTAD shall be capable of continuous operation over an ambient temperature range of -40°F to 165°F (-40°C to 74°C). The CTAD shall be capable of continuous operation over a relative humidity range of 5% to 95% (non-condensing).

Each CTAD shall be Federal Communications Commission (FCC) certified under CFR 47, part 15, section 15.245 or 15.249 as an intentional radiator. The FCC certification shall be displayed on an external label on each CTAD according to the rules set forth by the FCC. The CTAD shall comply with FCC regulations under all specified operating conditions and over the expected life of the CTAD. The CTAD shall comply with the applicable standards stated in the NEMA TS2-1998 Standard. Third party test results shall be made available for each of the following tests:

- Shock pulses of 10 g, 11 ms half sine wave
- Vibration of 0.5 g up to 30 Hz
- 300 V positive/negative pulses applied at one pulse per second at minimum and maximum DC supply voltage
- Cold temperature storage at -49°F (-45°C) for 24 hours
- High temperature storage at 185°F (85°C) for 24 hours
- Low temp, low DC supply voltage at -29.2°F (-34°C) and 10.8 VDC
- Low temp, high DC supply voltage at -29.2°F (-34°C) and 26.5 VDC
- High temp, high DC supply voltage at 165.2°F (74°C) and 26.5 VDC
- High temp, low DC supply voltage at 165.2°F (74°C) and 10.8 VDC

The CTAD shall be manufactured and assembled in the USA. The internal electronics of the CTAD shall utilize automation for surface mount and wave solder assembly, and shall comply with the requirements set forth in IPC-A-610C Class 2, Acceptability of Electronic Assemblies. The CTAD shall undergo a rigorous sequence of operational testing to ensure product functionality and reliability. Testing shall include the following:

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

Test results and all associated data for the above testing shall be provided for each purchased CTAD by serial number, upon request. The CTAD manufacturer shall provide both training and technical support services.

The manufacturer-provided training shall be sufficient to fully train installers and operators in the installation, auto-configuration, and use of the CTAD to ensure accurate CTAD performance. The manufacturer-provided training shall consist of comprehensive classroom labs and hands-on, in-the-field, installation and configuration training. Classroom lab training shall involve presentations outlining and defining the CTAD, its functions, and the procedures for proper operation. These presentations shall be followed by hands-on labs in which trainees shall practice using the equipment to calibrate and configure a virtual CTAD. To facilitate the classroom presentation and hands-on labs, the manufacturer-provided training shall include the following items:

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

Field training shall provide each trainee with the hands-on opportunity to install and configure the CTAD at the roadside. Training shall be such that each trainee will mount and align the CTAD correctly.

The manufacturer-provided technical support shall be available according to contractual agreements and a technical representative available to assist with the physical installation, alignment, and configuration of each supplied CTAD. Technical support shall be provided thereafter to assist with troubleshooting, maintenance, or replacement of CTADs should such services be required.

CTAD documentation shall include a comprehensive user guide as well as an installer quick-reference guide and a user quick-reference guide. The CTAD manufacturer shall supply the following documentation and specification test results at the time of the bid submittal:

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

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

The CTAD shall be mounted directly onto a mounting assembly fastened to a pole, overhead mast arm, or other solid structure. The CTAD mounting assembly shall provide the necessary degrees of rotation to ensure proper installation. The CTAD mounting assembly shall be constructed of weather-resistant materials and shall be able to support a 20-lb. load. The CTAD shall be mounted at a height that is within the manufacturer's recommended mounting heights. The CTAD shall be mounted at an offset from the center of the lanes of interest that is consistent with the CTAD's maximum offset. The CTAD shall be mounted in a forward-fire position, looking towards either approaching or departing traffic. The CTAD shall be mounted so that it is pointed within 10 ft. of the target point as defined by the manufacturer's table of target points for mounting offsets and mounting heights. The CTAD shall be mounted so that its vertical center line is within 5 degrees of the lanes of interest as described the manufacturer's documentation. Aligning the CTAD's center line with the roadway ensures that the antenna beam of the CTAD is positioned along the roadway. Two CTAD units shall not be mounted so that they are pointed directly at each other. CTADs that are mounted within 20 ft. of each other shall be configured to operate on different RF channels regard-less of the pointing direction of the CTAD. The CTAD shall not be installed in areas with overhead structures. For example, overhead sign bridges, tunnels and overpasses should be avoided. The CTAD shall be mounted at least 30 ft. to the side of any such overhead structures.

The cable end connector shall meet the MIL-C-26482 specification and shall be designed to interface with the appropriate MIL-C-26482 connector. The connector backshell shall be an environmentally sealed shell that offers excellent immersion capability. All conductors that interface with the connector shall be encased in a single jacket, and the outer diameter of this jacket shall be within the backshell's cable O.D. range to ensure proper sealing. The backshell shall have a strain relief with enough strength to support the cable slack under extreme weather conditions. Recommended connectors are Cannon's KPT series, and recommended backshells are Glenair Series 37 cable sealing backshells. The cable shall be Wavetronix # WX-SS-704, Allied Wire & Cable #091102-WGP-12 or an equivalent cable that conforms to the following specifications:

- The RS-485 conductors shall be a twisted pair.
- The RS-232 and RS-485 conductors shall have nominal capacitance conductor to conductor of less than 45 pF/ft at 1 kHz.
- The RS-232 and RS-485 conductors shall have nominal conductor DC resistance of less than 16.5 ohms/1000 ft. (304.8 m) at 68°F (20°C).
- The power conductors shall be one twisted pair with nominal conductor DC resistance of less than 11.5 ohms/1000 ft. (304.8 m) at 68°F (20°C).
- Each wire bundle or the entire cable shall be shielded with an aluminum/mylar shield with a drain wire.

The cable should be a single continuous run with no splices. Splicing, when deemed necessary, shall be done using a waterproof insulation displacement

connector, such as 3M ScotchLok. The cable shall be terminated only on the two farthest ends of the cable. The cable length shall not exceed the following limits for the operational baud rate of RS-485 communications:

Baud Rate Cable Length (NOTE: These represent maximum data rates. The data rate used should be the minimum data rate required for operation.)

115.2 Kbps 300 ft.

57.6 Kbps 600 ft.

38.4 Kbps 800 ft.

19.2 Kbps 1000 ft.

9.6 Kbps 2000 ft.

If communication is conducted over the RS-232 bus, then the RS-232 driver must be able to source and sink ±7 mA or more. The cable length shall not exceed the following limits for the operational baud rate of RS-232 communications:

Baud Rate Cable Length (NOTE: These represent maximum data rates. The data rate used should be the minimum data rate required for operation.)

115.2 Kbps 40 ft.

57.6 Kbps 60 ft.

38.4 Kbps 100 ft.

19.2 Kbps 140 ft.

9.6 Kbps 200 ft.

If 12 VDC is being supplied for the CTAD then the cable length shall not exceed 110 ft. If 24 VDC is being supplied for the CTAD then the cable length shall not exceed 600 ft. If a cable length of 600 ft. to 2000 ft. is required, the power cable shall be an ANIXTER 2A-1402 or equivalent cable that meets the following requirements:

- 10 AWG conductor size/gauge
- 2 conductor count
- Stranded cable type
- Bare copper material
- 600 V range
- 194°F (90°C) temperature rating

- PVC/nylon insulation material
- PVC—polyvinyl chloride jacketing material
- 25 A per conductor

Both communication and power conductors can be bundled together in the same cable as long as the above-mentioned conditions are met.

The CTAD shall be installed using lightning surge protection devices that meet or exceed the EN 61000-4-5 Class 4 specifications. The lightning surge protection unit shall be the Wavetronix Click!™ 222 or equivalent.

POWER SUPPLY: The CTAD shall be installed using the Click! 201, Click! 202 or an equivalent AC to DC power converter that meets the following specifications:

- The power converter shall be power rated at 15 W or greater at 77°F (25°C) and 10 W or greater at 165°F (74°C).
- The power converter shall operate in the temperature range of to -29°F to 165°F (-34°C to 74°C). The power converter shall operate in the humidity range of 5% to 95% at 77°F (25°C) non-condensing.
- The power converter shall accept an input voltage of 85 to 264 VAC or 120 to 370 VDC.
- The power converter shall operate at an input frequency of 47 Hz to 63 Hz.
- The power converter shall produce an output voltage of 24 VDC ±4%.
- The power converter shall have a hold-up time of greater than 20 ms at 120 VAC.
- The power converter shall withstand a voltage across its input and output of 2 kV. The power converter shall withstand a voltage across its input and ground of 1.5 kV.
- The power converter shall conform to safety standards UL 60950 and EN 60950.
- The power converter shall conform to EMC standards EN 55022 Class B and EN 61000-3-2, 3.
- In brown-out conditions (i.e. < 85 VAC input), the output voltage of the power converter shall be less than 1 VDC.

If input file cards are used in the detection system, then the Click! 112, Click! 114 or an equivalent that meets the following specifications shall be used.

1. The input file cards shall be compatible with 170, 2070, NEMA TS 1, and NEMA TS 2 style input racks.

2. The input file card shall translate data packets from the CTAD into contact closure outputs.

3. The input file card shall support actuation mode (passage detection output in real time) of operation.

4. The input file card shall receive data packets over an RS-485 bus at any of the following baud rates: 9600, 19200, 38400 and 57600 bps.

5. The input file card shall autobaud and auto-detect a CTAD over wired and wireless communication channels that have a maximum latency of 500 ms.

6. The input file card shall comply with the NEMA TS 2-1998 Traffic Controller Assemblies with NTCIP Requirements (Section 2.8 specification).

32. Tracing wire shall be installed on the inside of all empty conduits or conduits with only fiber optic cable to facilitate the locating of buried cable. The wire shall be either a No. 10 AWG stranded copper Type USE or THWN cable or a No. 12 AWG Copperhead cable. The trace wire shall be installed without splices. At each service or junction box, the trace wire shall be connected to a light duty Snake Pit device with an orange cap. Connection between the Snake Pit and the box shall be made with a 1-1/2" or 2" conduit sweep.
33. Conductors for power lead-in cable 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.
34. Insulation for power lead-in cable shall consist of cross-linked thermosetting polyethylene, meeting the requirements of column B of IPCEA and listed by UL as Type USE RHW-75° C.
35. The service enclosure shall be a combination meter socket breaker box, raintight enclosure equipped with a 100-amp main breaker and a 50-amp traffic signal breaker to be operated at 120 volts AC. The unit shall be capable of receiving 120/240 volt AC electrical line service. The unit shall be equipped with separate lockable compartments for the meter socket and the breaker box. Corbin locks shall be installed for parts of the enclosure that are accessed by the City. The unit shall be UL listed and the enclosure shall be natural aluminum. As per KCP&L requirements, the Contractor shall install the power cable and conduit from the KCP&L service point to the meter.
36. In addition to the requirements above, the service enclosure shall be equipped with a 240-volt, 30-amp street light circuit breaker, photocell and mercury contactor, test switch and appropriate terminal blocks for street light circuit connection when street lights are powered through the signal controller or when LED overhead street name signs are specified. The enclosure shall be specified on the Plans.
37. All conduit shall be as specified in the section of these Specifications entitled "Conduit".

38. Service boxes shall be fiberglass reinforced polymer concrete boxes of the size and shape as shown on the Standard Detail sheet in the accompanying plans. Service box material shall be an aggregate consisting of sand and gravel bound together with a polymer and reinforced with continuous woven glass strands. The material must have the following mechanical properties:

Compressive Strength	20,000 psi
Tensile Strength	1,700 psi
Flexural Strength	7,500 psi

39. Service boxes with an adjustable top ring shall not be permitted.
40. Junction boxes shall be Type I, Type II or Type III as shown on the plans and shall be fiberglass reinforced polymer concrete of a size and shape as indicated on the Standard Detail sheet in the accompanying plans. Junction box material to be an aggregate consisting of sand and gravel bound together with a polymer and reinforced with continuous woven glass strands. The material must have the following mechanical properties:

Compressive Strength -	20,000 psi
Tensile Strength -	1,700 psi
Flexural Strength -	7,500 psi

41. The actuated controller shall be a Rack Mount ATC Cobalt-C controller manufactured by Safetran and shall include the current firmware that is compatible with Operation Green Light (OGL).
42. All signalized intersections shall include a battery back-up system.
43. The Contractor shall provide a power transfer switch and shall attach it to the cabinet. The power transfer switch shall be manufactured by Gen Tran, Model No. FS300130, or approved equal.
44. The Contractor shall provide a rack-mounted power strip. The power strip shall have 12 power outlets – six front outlets and six rear outlets for ease of use. Power outlets shall be at a right angle and well-spaced so wall warts can easily be plugged into the power strip. The power strip shall also have an on/off switch that is protected to prevent it from being accidentally turned off. The power strip shall be manufactured by Tripp-Lite, Model No. RS-1215-RA, or approved equal.
45. The cabinet shall be a Model 332D and shall include an 8-inch riser. A Model 332 or 336 may be used only if specified in the accompanying plans. The cabinet shall be equipped with the appropriate number of the following equipment to allow for the traffic signal operation as shown in the accompanying plans:

Model 200 switch pack
Model 204 flasher

Model 420 flash transfer relay
Model 242 two-channel isolator
Loop detectors
Model 2018 conflict monitor

The cabinet shall be equipped with a combined power supply and power distribution assembly (PDA #2).

46. The output file back panel shall be handwire instead of printed circuit board. An auxiliary output file shall be provided where necessary.
47. The flasher program plug shall be accessible without dropping the output file back panel.
48. A red monitor board assembly shall be attached to the rear panel of the output file. A 20-conductor cable assembly for monitoring the red outputs of all signal load switches shall be provided and attached to the red monitor board assembly. The cable is to be routed to the front of the output file and plugged into the connector provided in the front of the conflict monitor.
49. A means of selecting the active red monitor channel shall be provided on the red monitor board assembly. Selection is accomplished by a two-position jumper (shunt) with the center position wired to a red monitor input and a select of 115 VAC to the right and the red load switch output to the left. Moving the jumper to the right will provide a continuous red input and override, while moving the jumper to the left will attach the monitor channel to the corresponding load switch output.
50. The jumper assembly shall be accessible while the intersection is in operation. Twelve selectors (12) shall be provided; eight phase selections and four overlap selections.
51. Two pull-out, hinged-top drawers having sliding tracks with lockout and quick-disconnect features, shall be provided as shown in the cabinet drawings. The pull-out drawer shall extend a minimum of 14 inches in order to facilitate removal of the processor by providing the processor with an aluminum platform covered by a Formica-type, chemical-proof plastic sheet while the rear connector is being removed. It shall be possible to lift this hinged platform in order to gain access to the interior of the drawer. Minimum interior dimensions of the drawer shall be 1 inch high, 13 inches deep and 16 inches wide. The drawer shall be capable of supporting a 40 lb. controller when fully extended. One drawer shall be located on each side of the cabinet. On the open side of the cabinet, two shelves shall be provided in addition to the pull-out drawer.
52. The Actuated Controller Operating Software shall be the latest version of ASC/3 firmware, as specified on the City's pre-approved list of materials, and shall already be programmed in the controller. Licensure of the program shall be included and made part of the controller unit in the name of the City of Lenexa, Kansas.
53. The cabinet and doors shall be fabricated from 0.125" minimum thickness unpainted aluminum. The cabinet shall be supplied with CORBIN #2 locks. Four 15-watt LED light fixtures and bulbs shall be provided, two each near the top front and back of the cabinet. The light shall be activated by an automatic switch activated when the door is open. The light fixture shall have a cold-weather type ballast. The cabinet shall be provided with lightning protection on the power input. A 1U 20A power strip shall be provided to power the PTZ cameras and switch, this power strip shall be plugged into a separate 120V (NEMA) 5-20P outlet receptacle.
54. In addition to the standard specifications, the conflict monitor shall be capable of monitoring the red signal outputs as described below:

    - Any dark signal head (that is loss of signal output to field terminals) shall cause the monitor to trip.

- The green, yellow and red indications for each phase shall be brought into the monitor individually and shall be monitored separately with respect to a loss of signal on any of the three (3) inputs per channel.
- The monitor shall have the required circuitry to allow the early detection of a conflict caused by a green or yellow signal "hang up" (that is any green or yellow output which shall remain on when the controller has transferred to a yellow or all red output respectively) by starting the fault timers as soon as a yellow appears with the corresponding green still energized. The monitor shall not wait until a conflicting green is displayed to time the conflict. This shall preclude the presentation of a conflicting signal display at the intersection.
- During the "All Red" clearance period, the monitor shall check all inputs for faulty signal display and shall react to these faulty indications during the all red clearance period. Since the only inputs that should be active during this period would be the reds, the monitor shall detect any faults such as red/green, red/yellow, green/yellow and green/red/yellow.
- The monitor shall be capable of monitoring for incorrect signal applied at the field terminals of each vehicular movement (green, yellow, red). Should a voltage be present on more than one, or none, of the inputs (green, yellow, red) of a channel, the unit shall begin timing the duration of this condition. If this condition exists for less than 700 milliseconds, the unit shall not trigger. If this condition exists for 1,000 milliseconds or more, the unit shall trigger. If this condition exists for 700 milliseconds or more, but less than 1,000 milliseconds, the unit may or may not trigger.
- When the unit triggers, it shall cause the output relay contacts to transfer. These contacts shall remain in this state until the unit is reset by the activation of the panel control or the activation of the external reset input. Power interruption shall not reset the conflict monitor when it has been triggered by detection of a faulty load switch output.
- The monitor shall be compatible with LED and flashing yellow arrow technology and be capable of testing on an ATSI PCMT 2600 model tester.

55. The minimum indicators shall be as follows:

- Power - Shall be illuminated when the +24 VDC input from the controller is present and AC+ is applied to the monitor.
- Watch Dog Error - Shall illuminate when the monitor detects a watch dog error, and shall be a 1.5 second watch dog circuit.
- Conflict - Shall illuminate when a conflict has been detected by the monitor.
- Red Failure - Shall illuminate when a red failure has been detected by the monitor.
- Switch Fail - Shall illuminate when a faulty load switch has been detected by the monitor.
- PCA - Shall illuminate when the program board is not installed or not installed properly.
- PIAF - Shall illuminate when the unit has detected a failure, and then experiences a power interruption.

52. The monitor shall include signal status indicators. These indicators (one per channel) shall illuminate when a signal is present on the corresponding channel during normal operation. If the unit trips due to a conflict, the signal status shall

lock up, displaying the status of each channel at the time the conflict occurred. Should the monitor trip due to the absence of red or a faulty load switch output, the signal status indicators shall display the channel (channels) which is (are) at fault. If the monitor detects a load switch fault condition, the switch failure indicator shall be illuminated on and the signal status indicators will display the exact channel of the load switch that failed. The red inputs shall be brought into the monitor via a front panel connector. The Red Enable shall be brought into the monitor via the same front panel connector as the red inputs.

53. The Contractor shall furnish and install Opticom emergency preemption equipment Opticom Model 764 phase selector as shown in the plans and as specified in the Traffic Signal Quantities. The cable shall be run continuous from the detector to the controller cabinet with no splices. The detector shall be installed as shown in the plans or by a method approved by the Engineer. The Contractor shall be responsible for the proper alignment of the detector to ensure maximum detection time for the emergency preemption equipment. This opticom equipment shall be programmable to restrict use by unauthorized users and shall have the capability to connect to the TCP/IP network.
54. The video detection system shall be Autoscope Solo Pro, Iteris or approved equal. The equipment shall include high-resolution color video image sensors, image sensor interface panels, detector port masters, and any other appurtenances necessary for the installation of a complete, operational, TCP/IP networkable video detection system. When specified in plans, the system shall include necessary hardware to allow for an Ethernet connection to a TCP/IP network via RJ-45 connection, and have the ability to be addressed using a four-octet address in accordance with TCP/IP (e.g. 255.255.255.255). System software shall allow for connection to the video detection system via Internet and/or private intranet connection.
55. The primary communications link media shall be a six pair minimum 18 AWG, 24 VCD or 115 VAC camera power cable. Continuous field communications links shall be used. Splices of any type are prohibited.
56. Lightning and transient surge suppression devices shall be installed on the processor side of the field communications link to protect the peripheral devices. Solid-state suppression devices shall be used that present high impedance to, and do not interfere with, the communications lines during normal operation. Suppression devices shall be used that do not allow the peak voltage on any line to exceed 300 percent of the normal operating peak voltage at any time. Devices with a response time that does not exceed five nanoseconds shall also be used.
57. All necessary software, modems, Ethernet cards and cables will be supplied at the central control location and on a portable laptop computer for the City of Lenexa providing the ability to monitor the operation and modify detector placement and configuration parameters. The computer will be provided by the City.
58. All lighting equipment including, but not limited to luminaires, lamps and poles shall conform to the City of Lenexa's Design Criteria and Plan Requirements as well as the Specifications.
59. All wood span wire poles, messenger cable, tether cable, guy wires, down guy anchors and cable clamps shall be as listed on the accompanying plans.
60. All permanent traffic signing and traffic control signing shall conform to the requirements of the Manual on Uniform Traffic Control Devices (MUTCD). All signs shall be fabricated from standard aluminum blanks utilizing high intensity reflective sheeting as called for in the accompanying plans, with the exception of

LED-illuminated overhead street name signs. Sign banding shall be 3/4” stainless steel.

61. Overhead street name signs shall be provided and installed on all mast arm poles and shall be either LED-illuminated overhead street name signs or signs constructed of 0.125” aluminum sheeting, as indicated on the plans. Minimum size requirements for any overhead street name sign shall be 18" x 60". All signs shall have the legends centered on the face with the letters or numbers spaced to produce a readable, professional quality sign. Sign legends shall contain an initial uppercase letter followed by lowercase lettering and shall be 12” series E lettering or numbers, unless otherwise stated on the plans. In addition, all lettering and numbers shall be white in color. Actual size drawings of the proposed signs shall be submitted to the Engineer for approval.
62. All aluminum sign faces shall be high intensity prismatic reflective sheeting. Aluminum signs shall have a white 0.75” wide border and shall have green backgrounds. Bolt hole locations shall be field located and drilled or punched for proper installation. Signs shall be mounted to the mast arms using Astro-Brackets. There shall be a minimum of two brackets per sign placed no more than 3 feet apart with a maximum of 1 foot from the edge of the sign.
63. LED overhead street names signs shall have a white border and a green background. The sign fixture shall be designed and constructed to prevent deformation or failure when subject to wind loads in conformance with the requirements of the AASHTO publication, Standard Specifications for Structural Supports of Highway Signs, Luminaires and Traffic Signals, and all associated updated amendments. All materials used in fabrication shall be new and of good quality.
64. All LED-illuminated sign materials furnished by the manufacturer/vendor/contractor shall be in accordance with the NEC and shall conform to the requirements shown below. The manufacturer shall supply shop drawing submittals for the fixtures, sign, sign message and mounting hardware. The LED-illuminated sign frame/housing shall be formed and manufactured out of extruded aluminum alloy with a minimum tensile strength of 20,000 ksi. The sign frame shall be painted flat black with a durable powder coat process. The sign frame/housing shall incorporate stainless steel fasteners provided at all the corners of the sign panel frame to secure the sign in the closed position. Weep holes shall be located at strategic points at the bottom of the housing to allow drainage of any condensation. The design of the housing shall afford provisions for continuous gasketing between housing and sign frame members to resist entrance of moisture, dirt and insects. Gaskets between sign panel frame and panel shall be closed cell neoprene rubber installed in the frame channel to prevent the gasket from moving or slipping out of position. The sign panel shall be slide-mounted in the frame, as shown on the plans. The entire surface of the sign panel shall be evenly illuminated. The light transmission factor of the sign panel shall provide a letter to background brightness ratio, which is adequate for nighttime legibility. The sign panels shall be translucent panels of high impact and UV resistant plastic/acrylic material. All surfaces shall be free from blemishes in the plastics or coating that might impair the surface or detract from the general appearance and color of the sign.
65. The LED-illuminated sign shall be mounted to the mast arm attached to the signal pole, as shown on the plans and in accordance with manufacturer’s recommendations. Unless otherwise shown on the plans or required in this specification, all fasteners and screws in or on the fixture shall be stainless steel

type 302 or 305, brass or aluminum. All steel nuts, bolts and hardware for sign attachment shall be stainless steel type 303 or 305.

66. The LED-illuminated sign light source shall be comprised of white LEDs projecting light into the border of an optically coupled light panel. The light panel redirects the light to create a uniform illuminated plane. Each sign shall use combinations of 12" x 1" printed circuit boards which incorporate 20, 25, or 30 white InGAN 5mm "ULTRA BRIGHT: LEDs. For each linear foot of sign, a combination of one top and one bottom printed circuit board format shall be used. Each board shall be replaceable and interconnected by locking male and female dual pin connectors. The operational life of the LEDs shall be a minimum of 10 years at 50% duty cycle.
67. The LED-illuminated sign shall be powered by 120 volts AC. The photocell on the Myers MET2-VLM-LTS service enclosure shall be used for the LED overhead street name signs. The manufacturer shall warranty workmanship and defects of the LED-illuminated sign under this specification for a period of five years.
68. All wiring connections within the sign fixture shall terminate through a UL approved junction box. All conductors inside the sign fixture and on the load side of the power shall be UL listed appliance material (AWM) stranded copper wire with thermoplastic insulation. All printed circuit boards shall be conformably coated for moisture resistance. The sign shall incorporate over-current protection through the use of an in-line fuse. The fuse rating and type shall be appropriate for varying size and power configurations.
69. Before commencing the installation of the traffic signal installation, a complete schedule of materials and equipment proposed for installation shall be submitted to the Engineer for approval. This schedule shall include catalog cuts, diagrams, drawings, and other such descriptive data that may be required by the Engineer.
70. All submittals shall include the manufacturer brand name and part number where applicable. Where more than one item is present on a submittal sheet, the appropriate item or items shall be circled, <u>not highlighted</u>. All submittals shall be organized as much as practical in order with the summary of quantities sheet in the plans. <u>One electronic</u> copy of each submittal shall be supplied to the City for review and approval. In the event that any materials or equipment contained in the schedule fail to comply with specification requirements, are not circled, or submittals are not packaged, such items may be rejected. New submittals on rejected items shall be supplied to the Engineer for approval.
71. When it is required by these specifications that a test be made of the material to be used on the project, the Contractor shall furnish the Engineer a certified copy of such test prior to the installation of such material. When any reference is made in these specifications to any specification such as ASTM, IPCEA, AIEE, etc., or a related specification referred to by reference therein, or revision thereof which states that a certain test, or tests are to be made only at the request of the purchaser, it shall be considered that the Engineer does request such test or tests to be made at the Contractor's expense and <u>one certified copy</u> of same be furnished as above mentioned.

B. CONSTRUCTION REQUIREMENTS:
   1. Within twenty (20) days following execution of a contract, the Contractor shall submit to the Engineer for approval the shop drawings as required in the "MATERIALS AND EQUIPMENT" section above.
   2. A pre-construction conference shall be held with the Contractor and the Engineer as directed by the Engineer.

3. The vehicle detection system shall be maintained by the Contractor throughout the project and shall be fully operational and functional at all times except for a short time period while the existing signal is switched over to the new signal.
4. At the earliest possible time, all electrical conduit, service boxes, pole foundations and junction boxes shall be installed at the correct grade.
5. Traffic signal heads shall remain covered with ORANGE bags during construction until the entire installation is placed in operation. Black bags shall not be used to cover the new signal heads during construction. Signal heads are to be covered to convey to drivers that they are not operational, as approved by the Engineer.
6. The Contractor is hereby advised that the work to be done shall be completed with full knowledge of the schedule made available to the Engineer. The Engineer may, at his option, cause any work completed without his knowledge or inspection, to be dismantled and inspected.
7. Any requested deviation from the "ORDER OF WORK" established herein must be approved by the Engineer or his representative.
8. No new fixture shall be constructed as part of this contract which is in conflict with any existing utility facility, or the code required thereby, unless approved by the Engineer.
9. Service and junction boxes shall be installed as shown on the plans and on the Standard Detail sheets and at such additional points as the Contractor, at his own expense and with the approval of the Engineer, may desire to facilitate the work. Unless otherwise directed by the Engineer, all service and junction boxes shall be installed level to 1 inch above the finish grade.
10. Conduit shall be installed as shown in the plans and the Standard Detail sheets and in conformance with the section of these Specifications entitled “Conduit”.
11. The Contractor shall perform all excavations for installing underground conduits, cable, boxes and pole bases in whatever substances encountered, to the depths indicated on the drawings or as otherwise approved. During excavation, material suitable for backfilling shall be piled in an orderly manner a sufficient distance from the excavation to avoid slides. Excavated materials shall be kept off sidewalks and out of the street where possible. Excavated material that is piled on sidewalks or in streets shall be removed by the end of the same working day. The Contractor shall pile excavated materials such that drivers' visibility will not be obstructed. All excavated materials not required or unsuitable for backfill shall be removed and wasted on a site obtained by the Contractor. Excavations and trenches shall not be larger or wider than necessary for the proper installation of the foundations or electrical appliance. Excavation shall not be performed until immediately before the installation of conduit, bases or other appliances. All excess excavated material shall be removed at the earliest possible time or as directed by the Engineer.
12. All areas excavated shall be backfilled and compacted in accordance with these Specifications. Backfill shall be deposited in not over 6” layers and tamped to 95 percent density ±3 percent of optimum moisture. The top 6 inches of backfill shall be select soil suitable for sodding. All areas excavated shall be backfilled at the earliest possible time or as directed by the Engineer. After backfilling, all disturbed areas shall be kept well filled and maintained in a smooth and well drained condition until permanent repairs are made. Where trenches are excavated in established sod areas, the area shall be backfilled the same day excavation occurs by a method approved by the Engineer. Approved methods are intended to reduce damage to the established sod area.

13. The bottom of the concrete foundations shall rest on firm ground; foundations shall be poured monolithic except the top 6” pole cap. The exposed portions shall be formed to present a neat appearance. Forms shall be true to line and grade. The top of concrete foundations, except special foundations, shall be finished to either sidewalk grade or 1 inch above finished grade, as directed by the Engineer. Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be placed in proper position, to proper heights, and held in place by means of a template until the concrete sets. Each anchor bolt shall be provided with 2 hex head nuts, 2 flat washers and 1 lock washer. Both forms and ground which will contact the concrete shall be thoroughly moistened before placing concrete. All conduits shall be securely covered prior to pouring concrete. All threaded portions of anchor bolts shall be taped during the concrete pour. Any concrete splashed on poles when pouring the pole cap shall be immediately cleaned off.
14. Installation of wiring shall be in accordance with the plans and specifications and appropriate articles of the National Electrical Code. In addition, allowable pulling tensions on wiring in conduits shall be as per the cable manufacturer's recommendations. Approved pulling lubricants shall be used when pulling wiring in conduits. No splicing of cables will be permitted unless shown on the plans or approved by the Engineer. Where splices are allowed, they shall be made by a method approved by the Engineer. Wire nuts shall be used in the base of any signal pole for wire connections.
15. Where practical, color codes shall be followed so that the red insulated conductor connects to the red indication terminal, orange to yellow, green to green and white to neutral. In addition, signal cable shall also be color-coded as follows:

    - Cable runs for northbound traffic: Color code BLUE
    - Cable runs for southbound traffic: Color code PURPLE
    - Cable runs for eastbound traffic: Color code YELLOW
    - Cable runs for westbound traffic: Color code RED
    - Cable runs for northbound left-turning traffic: Color code BLUE with ORANGE
    - Cable runs for southbound left-turning traffic: Color code PURPLE with ORANGE
    - Cable runs for eastbound left-turning traffic: Color code YELLOW with ORANGE
    - Cable runs for westbound left-turning traffic: Color code RED with ORANGE

16. A minimum of one (1) turn of each cable shall be left in every service or junction box for slack. In addition, slack shall be left in all poles and the controller cabinet. All slack cable shall be neatly dressed using nylon cable ties.
17. Bonding jumpers shall be No. 6 AWG bare copper wire or equally connected by approved clamps. Grounding of neutral at service point shall be accomplished as required by the National Electric Safety Code, except bonding jumpers shall be No. 6 AWG or equal. Ground electrodes shall be provided at each signal pole and pedestal and at the controller as detailed on the plans. The controller requires an equipment ground as indicated on the Standard Detail sheets in the plans.
18. All poles and pedestals are to be installed as shown in the plans and the Standard Detail sheets. All attachments are to be located in the field and all wire

entrances shall be drilled or punched in the field. All drilled or punched surfaces shall be carefully reamed and/or deburred or threaded as appropriate before an application of one field coat of cold galvanizing. The Engineer shall confirm the location and mounting heights of all pole and pedestal attachments located in the field. Should field adjustment of any attachment be necessary after the Engineer confirms the locations, the Contractor shall be responsible for plugging any holes caused by the initial installation. Hole plugging methods shall be approved by the Engineer.

19. Mast arms on mast arm poles shall be installed after the mast arm poles are erected. In some instances and depending upon the final locations of the signal poles, a short section of the mast arm(s) may need to be cut off, as directed by the Engineer, in order to accommodate varying field conditions.
20. Signal heads shall be installed as shown on the plans and the Standard Detail sheets. The Engineer shall approve the location, mounting and mounting height of all signal heads. Signal heads shall not be installed at any intersection until all other signal equipment, including the controller cabinet, is in place and ready for operation at that intersection, except that the signal heads may be mounted if the faces are not directed toward traffic (refer to the beginning of “ORDER OF WORK”)
21. The signal heads shall be adjusted in the field such that a person standing on the pavement, a distance of four times the speed limit (mph) in feet (0.8 times the speed from the stop bar, shall see the brightest image of the red section. All heads shall be plumbed as viewed from the direction in which they face.
22. Loop detector installation shall conform to the details and notes shown on the plans and the Standard Detail sheets. All loop conductors shall be wound in the same direction with the start and end clearly marked on the conductors at the junction or service box. Conductors of all loops shall run continuous to and from the nearest junction or service box. The loop conductors for each loop shall be spliced in the junction or service box to a detector lead-in cable running from the box to a sensor unit mounted in the controller cabinet.
23. When construction of a loop is started, it shall be completed the same construction day. Should the Contractor start a loop installation and fail to satisfactorily complete it, the entire loop may be subject to replacement at the discretion of the Engineer. Construction of loops shall only be started when the ambient air temperature is 40° F. and rising.
24. Saw cuts for loop wires shall be made with a self-propelled saw with a water-cooled blade. The water is used to cool and lubricate the blade and eliminate blowing saw dust. Water shall be provided by the Contractor. All jagged edges or sharp corners and protrusions shall be removed using a small chisel and hammer. The saw cut shall be cleaned to remove cutting dust, grit, oil and other contaminates. The saw cut and entire loop area shall be flushed clean with water and dried with compressed dry air immediately after cutting. Care shall be taken during the cutting and cleaning operation to avoid blowing debris at passing pedestrians and vehicles or onto private property. All corners of loops will be drilled with 1.5 inch to 2 inch hole drill to the depth of saw cut.
25. Detector loops shall be installed in the asphalt base course prior to the placement of the asphalt surface course.
26. Wire shall be installed so as to minimize stress at corner locations. Wire shall be kept dry when installing in the saw slot and shall be inserted by use of a blunt, preferably nonmetallic, flat paddle.

27. After conductors are installed in the slots cut in the pavement, the slots shall be filled with the approved sealant to within 1/8 inch of the pavement surface. The sealant shall be prepared and installed in accordance with the manufacturer's recommendations, as approved by the Engineer. The sealant shall be between 1-1/2 inches and 2-1/4 inches thick above the top conductor in the saw cut as determined by the saw cut depth and as indicated in the plans. Before setting, surplus sealant shall be removed from the adjacent road surfaces without the use of solvents.
28. The Contractor shall allow time to let the sealant set before opening the lane(s) to traffic. Approved absorbent material shall be spread over the sealant if traffic is allowed over the loop before the sealant is completely set, as determined by the Engineer.
29. The video detection system shall be installed according to the manufacturer's requirements and the Contract Documents. The Engineer shall be provided with three (3) copies of the manufacturer's written requirements. The video detection system configuration consists of the number of cameras and video detection systems shown in the Contract Documents. The actual quantity and proposed location of the equipment to be furnished installed and made fully-functional as a complete video detection system by the Contractor is shown in the Contract Documents. The supplier of the video detection system shall supervise the installation and testing of the video and computer equipment. A factory-certified representative from the supplier must be on-site during installation. In the event that the filed-setup computer is provided by the owner, the installation and testing shall be done at the time that training is conducted.
30. A two-year manufacturer's warranty covering the entire Video Detection System shall be provided. The warranty period will begin upon acceptance of the video detection system by the Engineer. The warranty shall cover ongoing software support by the supplier to include updates of the video detection system processor unit, modular cabinet interface unit and supervisor software (if a field setup computer is required for setup). These updates must be provided free of charge during the warranty period. The update of the video detection system software shall be compliant with the NEMA TS2, the Cal Trans 170 or 2070, and National Transportation Communication Interface Protocol (NTCIP). The supplier shall maintain a program for technical support and software updates following expiration of the warranty period. This program shall be made available to the owner in the form of a separate agreement for continuing support.
31. The signal turn-on shall be performed by City personnel and the Engineer. The Contractor shall be present for signal turn-on and be prepared to respond to any technical difficulties that may be encountered due to construction of the traffic signal. The signal turn-on shall not occur on Fridays, holidays or weekends and shall be completed between the hours of 9:00 a.m. and 2:00 p.m. unless otherwise noted in the plans or directed by the Engineer. At locations without previous traffic signal control, the new traffic signal shall flash for a period of two to three business days prior to full signal system turn-on.
32. All traffic signal installation elements shall function properly as a complete system for a minimum period of fifteen (15) calendar days before acceptance by the City.
33. The traffic signal shall function under normal conditions for a fifteen (15) calendar day continuous time period. During this fifteen (15) day test period, the signal operations shall be continuous without malfunctions. Any malfunction observed

or recorded shall stop the test period as of the time of the malfunction and the test period shall not resume until all components are satisfactorily operating.

34. The Contractor shall be present to assist and participate in inspections of the traffic signal installation prior to final acceptance.
35. The work included in this project may involve modification of existing traffic signal equipment at locations which are presently controlled by operating traffic signals. If portions of the existing traffic installations are to be incorporated in the proposed signal installations, the following policies are to be observed during the installation of the proposed modifications and improvements:
36. The existing signal controls shall be kept in operation during installation of the proposed signal modifications and improvements, except for shutdowns to allow for alterations as required for installation of the proposed improvements.
37. Some periods of disruption to existing signal operations can be tolerated during installation of the proposed improvements. However, the Contractor shall coordinate planned disruptions of signal operations with the Engineer a reasonable time in advance of such disruption of operations. The Contractor shall be responsible for maintaining adequate traffic control during any period of disruption to the existing signal.
38. 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 proposed modifications and improvements.
39. Planned disruptions of signal operations shall be restricted during off-peak time periods as directed by the Engineer. The signal controls shall be operable during all other periods.
39. All existing salvageable equipment, as determined by the Engineer, (i.e. signal heads, brackets, luminaires, poles, arms, controllers and cabinets) that is in excess of the requirements of this project shall be completely removed from the project. The Contractor shall deliver same equipment to the City of Lenexa Municipal Services Traffic Division. The Contractor shall be responsible for any damage or loss of salvageable equipment. All new equipment purchased as spare parts under the requirements of this project shall be delivered new and undamaged to the City of Lenexa Municipal Services Traffic Division, and stockpiled as per the instructions of the Engineer. The Contractor shall exercise care in the removal and delivery of any existing or new equipment to be delivered to the City. All salvaged equipment shall be re-usable, including Astro-brackets. All non-salvaged items of existing equipment shall become the property of the Contractor.
40. All concrete bases removed shall be broken up and removed to a depth of twenty-four (24) inches below grade. Holes resulting from this operation shall be filled to the proper grade with suitable material approved by the Engineer.
41. Specifications regarding traffic control for signal installations can be found in the section of these Specifications entitled “Traffic Control”.

C. METHOD OF MEASUREMENT: “Traffic Signal” installation as indicated on the plans, complete-in-place and accepted, will be measured as a unit lump sum quantity for all work necessary.

D. BASIS OF PAYMENT: “Traffic Signal” installation, measured as provided above, will be paid for at the contract lump sum price bid, which price shall be full compensation for furnishing all equipment, materials, and all other work necessary or incidental to the

construction of the complete traffic signal installation and for all equipment, tools, labor and incidentals necessary to complete the work.