

S T A T E

O F

T E N N E S S E E

(Rev. 12-18-1995)

January 1, 2015

SPECIAL PROVISION

REGARDING

SECTION 730 - TRAFFIC SIGNALS

Add the following to end of the second paragraph of Subsection 730.02:

All Contractors engaged in the installation or modernization of traffic signals and all related equipment shall have an IMSA Level II Certified Technician on the job site whenever work is being done. The Contractor shall possess a Class 1 Electrical Contractors License issued by the City Of Knoxville.

Add the following to end of Subsection 730.03:

A copy of all submittal data and mill test reports shall be provided to the City of Knoxville.

Delete Subsection 730.05 and substitute the following:

730.05 - Documentation Packages. Documentation packages shall be delivered at the same time as the equipment to which it pertains. The required documentation packages as a function of units delivered is given below:

<u>NUMBER OF UNITS</u>	<u>NUMBER OF DOCUMENTATION PACKAGES REQUIRED</u>
1 - 5	5
1 - 15	8
1 - 30	10
Over 30	15

Contents of Documentation Packages

Parts - Identification - The documentation packages shall contain a method of parts-identification that shows the location of every individual component. This includes integrated circuits, transistors, resistors, capacitors, inductors as well as test points, switches and indicators. Parts-identification shall be imprinted, stamped or etched on

circuit boards in addition to providing a pictorial layout. Such markings shall in no way be obscured from normal viewing as a result of parts mounting and shall be referenced to the schematic.

Parts Replacement - The documentation packages shall contain a parts replacement guide so that any component needing replacement can be identified. It shall be possible to use the parts replacement guide for information to either find an industry standard replacement part or order a needed component from the manufacturer. All components that are not standard components readily available from commercial electronics supply outlets shall be identified in the documentation package.

Schematics - The documentation packages shall include a schematic of each component and printed circuit board to include identification of all parts and terminals. All schematic symbols for digital circuits shall conform to the latest revision of Military Standard 806 (except size requirements for symbols of 806).

Data on all I.C.'s shall consist of at least a schematic symbol, a truth table and identification of pin setting and their functions.

Installation procedures - The documentation packages shall include complete electrical and mechanical installation procedure for each type of unit. Procedures shall be precise and easy to understand.

Maintenance procedures - Maintenance and trouble-shooting procedures shall be included and referenced to the schematics so that block checks can be made to locate any defective components. Point to point voltages shall be included that are pertinent to proper servicing. Test points must be easy to locate and contact with test instrument probes. The controller shall have resident diagnostics that will allow the operator to address and read any location in RAM memory. The controller shall have a standard RS-232 port.

Descriptions - A complete physical description of the units shall be provided to include at least the physical dimensions of the unit, weight, temperature ratings, voltage requirements, power requirements, material of construction, and complete performance specifications.

Operation Guides and Users Manuals - A complete set of operation guides and user manuals shall be provided.

These documents shall fully cover all programming procedures and programmable options capable of being made to the controllers and associated traffic control equipment. Detailed instructions for modifications within the range of the capabilities of the unit such as changes in phases or sequences and programming matrix boards shall be included.

Inventory - For each type of controller unit to be supplied, a list of each type of each type of module, subunit or complete unit contained within the unit or cabinet shall be provided.

Delete Subsection 730.07 and substitute the following:

730.07 - Training Sessions. The supplier shall provide one training session for the City of Knoxville on the theory of operations, installation, and maintenance of all equipment supplied under the contract. The session shall be clear and detailed to the degree that the instruction presented will give the City of Knoxville engineering and maintenance staff the information needed to carry out the necessary maintenance and operation procedures. All training will be conducted by a qualified factory instructor.

Training Time - Training session shall be a minimum of sixteen (16) hours as outlined below.

Programming and Installation Training - A minimum of four (4) hours shall be required.

Internal Operation and Circuit Board Theory - A minimum of eight (8) hours shall be required.

Trouble Shooting and Diagnostic Procedures - A minimum of four (4) hours shall be required.

Schedule of the Session - The session shall be held following the complete delivery of the first shipment of traffic controllers. The date for the session will be within three (3) weeks of notification by the City of Knoxville, Department of Traffic Engineering.

Training Session Agenda - A proposed training session agenda including items to be covered during each day of the training sessions shall be submitted to the city of Knoxville, Department of Traffic Engineering for approval as soon as a mutually agreed upon date is determined for each session.

Location of Training Sessions - All training sessions shall be conducted at the City of Knoxville, Department of Traffic Engineering facilities between 8:00 a.m. and 4:30 p.m. on weekdays only.

This training requirement shall not apply if a training program meeting these criteria has been accomplished by this vendor and/or manufacturer on the equipment being bid; within eighteen (18) months previous to the date of this invitation to bid; but shall apply if the bidder is proposing new, upgraded, or modified equipment not covered in such previous training program.

Delete Subsection 730.16 and substitute the following:

730.16-Cable. All signal cable shall be 12 conductor and conform to applicable IMSA Specification No. 19 or 20. Stranded cable color coded AWG #14 shall be used for all signal and accessory circuits. All circuit runs shall retain the same color identification throughout its entire length. A minimum of 7 conductor cable is allowed to be used to wire pedestrian signals.

Delete the first five paragraphs of Subsection 730.24 and substitute the following:

730.24-Signal Heads. Each vehicle signal head shall be of the adjustable, colored lens, vertical type with the number and type of lights detailed herein and as shown on the plans; shall provide a light indicator in one direction only; shall be capable of adjustment (without attachments) through 360 degrees about a vertical axis; and shall be mounted as shown on the plans or as specified by the Engineer. The arrangement of the lenses in the signal faces shall be in accordance with Section 4B-9 of the MUTCD. All circular indications shall use 300 mm (twelve inch) lenses unless otherwise shown on the plans. All arrow indications shall use 300 mm (twelve inch) lenses. All new vehicle signal heads installed at any one intersection shall be of the same style and from the same manufacturer. All signal heads, signal head mountings, outside of hoods, and pedestrian push button housings shall have one or more coats of primer followed by two coats of Traffic Signal Yellow and shall meet or exceed Federal Specifications TTC-595 Gloss Yellow.

Louvers as specified, interior of signal hoods, and back plates shall have one or more coats of primer followed by two coats of Lusterless Black Enamel meeting or exceeding Federal Specifications TT-E-489. All factory enameled equipment and materials shall be examined for damaged paint after installation, and such damaged surfaces shall be repainted to the satisfaction of the Engineer. Factory applied enamel finish in good condition and of appropriate color will be acceptable.

Suspensions for span wire mounting shall include a complete 12 circuit disconnect hanger assembly with associated span wire clamp. All wires, including unused conductors, shall be terminated to the appropriate numbered position currently used by the City Of Knoxville. Position 1 shall be located on the side of the disconnect, position 12 shall be on the right side of the disconnect and shall be used exclusively for the AC neutral wires of the signal cable. It is the responsibility of the Contractor to obtain the wiring color code before any construction is started.

All signal heads must meet the minimum requirements for adjustable face vehicle traffic control signal heads as specified in ITE Technical Report No. 1 (1970) and its latest revision.

All signal heads shall be polycarbonate. They shall be the same in appearance as metal signals except that the lenses, housings, doors, visors shall be molded of polycarbonate resin and shall withstand 95 J (70 ft-lb) impact without fracture or permanent deformation. The color of the signal shall be Federal yellow and shall be homogenous throughout. "Reflectors shall be "ALZAK" process coated aluminum or approved equal material and shall conform to the specifications of the ITE Technical Report No. 1 (1970) and its latest revision."

Delete the section under Optical Units in Subsection 730.24 and substitute the following:

Optical Units - All signal sections shall be 300 mm (12 inch). Signal lamps for 300 mm (12 inch) lenses shall be clear, 130 volts AC, 1750 rated initial lumen output, with a minimum life of 6,000 hours. Visors shall be held in place by a stainless steel screw and be removable without opening the door of the signal section. Lens shall be secured in place by means of screws and lens clips.

Delete Subsection 730.25 and substitute the following:

730.25 - Controllers. It is the purpose of this section of these specifications to set forth minimum design and functional requirements for all types of controllers included in the entire specifications.

Electrical Requirements

Power

Nominal Voltage and Current - The controller shall be designed to operate from a nominal 120 volt alternating current, 60 Hz power source.

Voltage and Current Ranges - The controller shall operate satisfactorily within a voltage range of 105 volts to 135 volts alternating current and a frequency of 60 Hz.

Controller Connections - The controller shall contain a circular twist lock type connector meeting the requirements of "Pin Connections", NEMA Traffic Control Systems Standards, latest revision.

Overcurrent Protection - The controller shall contain a front panel mounted AC power input fuse or circuit breaker of suitable size to provide adequate overcurrent protection.

Components

Printed Circuit Boards - ALL printed circuit boards shall meet the requirement of NEMA Traffic Control Systems Standards, latest revision, Printed Circuit Assemblies.

Operating Loads - Components operating under continuous load shall be derated as follows: Capacitors to maximum 75 percent of working voltage rating; resistors to a maximum 25 percent of wattage rating; solid-state components to maximum 25 percent of current rating.

Indicator Lights

Type - Solid state Light Emitting Diode (LED) or Liquid Crystal Display (LCD) shall be used. Indicators may be soldered directly to the associated printed circuit board. Removal of indicators shall not affect the operation of the unit in any way.

Visibility - Indicators shall be visible in sunlight.

Identification - All components shall be marked with standard industry (JEDEC, EIA, RETMA, etc.) approved color codes, symbols and identification alphanumeric characters (whichever applies or have a cross-reference part number. Any exceptions shall be approved by the Department. Suitable means of identifying components on the printed circuit boards shall be provided.

Design

Modularity - All controllers shall be phase and/or function modular and completely solid state in function. Gears, cam shafts, motors, reed switches, etc., shall not be used

for any functions within the controller. A minimum modularity of two (2) plug in subassemblies is required on the front panel.

Timing - Timing shall be digital; analog time is prohibited.

Other Features - It shall not be permissible to connect two controllers together for the purpose of increasing their control capacity. Special equipment not specifically covered by this specification shall be electronic and solid state in construction.

Power Supply - The power supply shall be easily removable from the main frame with the use of only common tools. The power supply shall have overvoltage and overcurrent protection for all D.C. plus D. C. minus voltages. The power supply shall be readily accessible. Maximum voltage permitted within the controller shall be 135 Volts.

Logic Voltage and Current Levels

Logic Signals - All logic signals shall be low state (nominal zero volts) for the TRUE (operate) state of all input and output terminations. Input-output terminations when not activated, shall be internally biased to the FALSE state (+24 Volts D.C.).

Input Characteristics - Inputs shall meet the requirements of NEMA Traffic Control Systems Standards, latest revision, Inputs.

Output Characteristics - Outputs shall meet the requirements of NEMA Traffic Control Systems Standards, latest revision, Section 3, TSI-3.2.4, Outputs.

Power Interruption - Power interruption shall meet the requirement of NEMA Traffic Control Systems Standards, latest revision, Section 2, TSI-2.1.4, Power Interruption.

Initialization - Initialization shall meet the requirements of NEMA Traffic Control Systems Standards, latest revision, Initialization.

Physical Requirements

Frame Requirements

Frame Requirements - All controllers shall be eight phase and contain all modules necessary to connect and place in operation with existing traffic systems, and contain all operational features described elsewhere in this specification.

Construction - The controller frame shall be of sturdy construction and shall be equipped with card guides and edge card connectors to receive the various plug-in modules. A minimum of two card guides (one for the top and one for the bottom) per module slot shall be furnished with the frame. The modules shall be interconnected by means of a motherboard assembly or other approved method.

Modules - Front panel modules shall be positively fastened to the frame by means of a captive nut and thumb screw type arrangement which shall require no tools to remove or replace. Each front panel module shall be removable and replaceable without the necessity of removing adjacent modules. Internal modules shall be easily accessible and removable without having to remove adjacent internal modules. No finger holes shall be permitted. It shall not be necessary to insert fingers between adjacent modules during removal.

Connectors - The A, B and C connectors shall be considered as part of the module. All connectors shall be metal.

Completeness - The controller frame shall also include all modules that are required to make the controller assembly operate as per these specifications.

Housing Requirements - The controller frame shall be furnished completely enclosed in a durable sheet aluminum (or approved alternate) housing, with a durable finish. The housing shall be designed to adequately dissipate the heat generated by the controller circuitry. The controller frame shall have the serial number permanently stamped, engraved or printed on the outside of the housing.

Modular Requirements - The controller frame shall be labeled above or below the module to indicate the phase or function the module is servicing in the controller. Each module shall have the model number or nomenclature of the manufacturer and the serial number permanently stamped, engraved or printed on it. The model number or nomenclature and serial number shall completely identify the module function and any jumpers or modifications thereon. The identification shall correspond to the information appearing in the documentation.

Constancy of Intervals - The length of any interval or timing settings shall not change by more than or less than 100 milliseconds of its set value so long as the voltage and frequency of the power supply and the ambient temperature inside the controller cabinet remain within the tolerances specified in these specifications.

Interval Sequence

Signalized Intersection Movement Assignments

Modifications - Phase assignments shall be field modifiable. It shall not be necessary to return the controller to the factory for this type of modification. The manufacturer shall supply detailed written instructions as part of the documentation package which will enable the City of Knoxville technical staff to alter the movement assignments. These instructions shall include adding standard overlaps. The controller shall contain a user programmable overlap card accessible via the front panel without removing or opening any modules or covers.

Skipping of Actuated Phases - If at the end of the green interval of the terminating phase, neither vehicle nor pedestrian memory indicates a need for the next traffic phase, the intervals which comprise that phase shall be omitted from the interval sequence. This does not, however, preclude the use of recall functions which, when asserted, shall cause the phase to be displayed even though no detector actuations have been received.

Basic Interval Setting and Functions

Provisions for Setting

General - The controller shall provide for the setting of each interval, portion of interval, or function by means of entering timing values through an approved keyboard. Timing shall be calibrated in seconds and fractions thereof. Setting of timing and function values shall be accomplished without use of special tools or wiring changes.

The controller shall contain a standard RS-232 port that can be used to program timing through the use of a personal computer.

Means of Setting Intervals - All interval settings shall be accomplished through the use of a keyboard located on the front panel. There shall be provisions for position indication of all parameters. Display shall be self-evident to permit verification of stored information. Steps required to use keyboard controls shall follow a natural sequence, misleading information shall not be displayed at any time. Controls shall be labeled and completely identified as to what their function and use is. Each controller shall have a keyboard entry front panel. No hex-code entries shall be required prior to entering any timing entries. Membrane type data entry keyboards are not acceptable.

Location of Controls - The interval and function controls shall be located on the front of the controller and shall be properly designated as to the function each control performs.

Required Intervals/Functions and Ranges - The required intervals, portions of intervals, and functions for each phase of operation shall be as listed in the table below.

Required Functions

<u>Interval (Function)</u>	<u>Minimum Range</u>	<u>Increment</u>
Initial	1 sec. - 30 sec.	1 sec.
Extension (Passage)	0 sec. - 9.9 sec.	0.1 sec.
Maximum I	10 sec. - 99 sec.	1 sec.
Maximum II	10 sec. - 99 sec.	1 sec.
Yellow Clearance	3.0 sec.*- 7.0 sec.	0.1 sec.
Red Clearance	0 sec. - 7.0 sec.	0.1 sec.
Walk	1 sec. - 30 sec.	1 sec.
Pedestrian Clearance	5 sec.*- 30 sec.	1 sec.

* A minimum of the value shown shall be guaranteed if no entry is made of if a time less than the value shown is entered.

Optional Volume/Density Operation

<u>Interval (Function)</u>	<u>Minimum Range</u>	<u>Increment</u>
Minimum Initial	1 sec. - 30 sec.	1 sec.
Added Initial/Actuation	0 sec. - 2.2 sec.	0.1 sec.
Actuation before		
Added Initial	2 veh. - 60 veh.	1 veh.
Passage Time	0 sec. - 9.9 sec.	0.1 sec.
Minimum Gap	0.5 sec. - 7.5 sec.	0.1 sec.
Time to Reduce to		
Minimum Gap	10 sec. - 99 sec.	1 sec.

Indicators - Indicators shall meet the requirements of NEMA Traffic Control Systems Standards, latest revision, Indicators.

Vehicle Recall Switches

Minimum - Minimum recall shall be accomplished for each vehicle phase through a keyboard entry which, when asserted for each vehicle phase, shall cause the automatic return of the right-of-way to that phase for a duration at least equal to the initial interval in accordance with the specified interval sequence.

Maximum - Maximum recall shall be accomplished for each vehicle phase through a keyboard entry which, when asserted for a phase, shall cause the automatic return of the right-of-way to the phase for the duration of the maximum green interval in accordance with the specified interval sequence.

Vehicle Detector Non-Lock Memory Switch(es) - A keyboard entry shall be provided for each actuated vehicle phase which, when asserted for a phase, shall cause the vehicle detector memory circuit for that phase to be disabled in the event vehicular traffic is not presently occupying the vehicle loop at the yield point of the cycle.

Pedestrian Recall Switch(es) - A keyboard entry shall be provided for each actuated phase that includes pedestrian interval timing functions, which when asserted, shall cause the automatic return of the controller to that phase and related pedestrian interval(s).

Flashing of Pedestrian Clearance Interval Functions - Means shall be provided to control the flashing of pedestrian signals during the pedestrian clearance interval through a keyboard entry.

Signal Circuits

General - The controller shall be provided with the following number of load switch sockets and circuits.

<u>Type Controller</u>	<u>No. Phases</u>	<u>No. Load Switch Sockets</u>	<u>No. Independent</u>
Type 1 ("M" Pole Mount)	4	8	24 (3 per load switch)
Type 1 ("M" Pad Mount)	4	8	24 (3 per load switch)
Type 2 ("P" Pad Mount)	8	12	36 (3 per load switch)

All functions specified in the NEMA pinlist or connector shall be terminated on a terminal block. No solid state load switches shall be required.

NEMA Triple Signal Load Switch Sockets - The load switch sockets shall utilize external jack-mounted load switches in accordance with "Solid-State Load Switch", NEMA Traffic Control Systems Standards, latest revision.

Conflict Monitor

All cabinets shall be supplied with a Signal Conflict Monitor (SCM) which meets the NEMA Standards. The SCM for all controller cabinets with three or more phases shall be the 12-channel type, and shall have the following features:

1. Liquid Crystal Display to show all data in English language format.
2. Shall monitor all Green/Yellow/Red/Walk field display outputs.
3. Shall monitor the Controller 24 VDC output and be user programmable to have this monitor function Latch on.
4. Shall monitor the Controller Voltage Monitor output, and be user programmable to have this monitor function Latch On.
5. Per Channel monitoring of Phase Yellow Clearance Interval, and shall cause flash operation if Yellow Clearance is less than the SCM programmed time (2.7 - 9 seconds).
6. Front panel mounted over-current protection (no internally mounted fuses are acceptable).
7. Front panel mounted reset switch.
8. Fault logging features:

The SCM shall log all faults as to the:

- a. Date of fault
- b. Time of fault
- c. The fault condition
- d. Power failure

and store these fault conditions in no-volatile memory for user retrieval. The monitor shall be able to store at least 10 such faults. The internal time clock shall automatically adjust for Daylight Savings Time changes. There shall be a keyboard method for the user to display and clear the stored event log.

9. There shall be an RS-232 port on the SCM to allow the user to print all data stored in the SCM. The printer shall interface with the SCM via a standard RS-232 cable. Printer to be supplied by others.
10. The SCM shall detect the following conditions and place the cabinet in the flash mode by De-energizing the Flash Transfer Relays:
 - a. Absence of an active AC input on a channel
 - b. Green/Yellow both active on a channel
 - c. Yellow/Red both active on a channel
 - d. Green/Red both active on a channel
 - e. Green/Green active on conflicting channels
 - f. Green/Yellow active on conflicting channels
 - g. Green/Walk active on conflicting channels
 - h. Low 24 VDC sample
 - i. Controller Voltage Monitor active

- j. Clearance time less than programmed
- 11. On circuits where all field outputs are not used (such as left-turn phases) unused circuits shall be terminated at a load resistor and the monitor plus features shall function
- 12. No functional field display shall be permitted unless monitored by the SCM
- 13. The SCM sampling inputs shall be terminated at the closest tie point to the field termination

Flashing of Signals

Requirements - Means external to the controller shall be provided to permit the substitution of flashing signal indications for the normal specified interval sequence.

Solid State Flasher - A solid state flasher with no contact points or moving parts shall be provided. The solid state flasher shall utilize zero-point switching. All physical characteristics and electrical characteristics shall be in accordance with "Solid State Flashers", of NEMA Traffic Control Systems Standards, latest revision.

Flashing of Vehicular Signals - Flashing of vehicular signal indications shall be obtained from one double circuit flasher capable of 15 amps per circuit. Flash transfer relays shall be rated a minimum of 30 amps at 120 VAC.

Manual Control

Manual Operation - For use under special conditions, controllers shall be provided with means for substituting manual operation of interval timing. Manual operation of interval timing shall provide the same interval sequence as when the controller is operating automatically. The controller shall provide manual operation in response to commands from external devices.

Manual Control Enable - Manual commands shall stop controller timing in all intervals except vehicle clearances, and inhibit the operation of interval advance during vehicle clearance.

Operation Without Pedestrian Timing - When concurrent pedestrian timing is not provided, one actuation of the interval advance input shall advance the controller to Green Rest from which it will immediately select a phase next and advance to the Yellow Vehicle Clearance, subject to the constraints of concurrent timing.

Operation With Pedestrian Timing - When concurrent pedestrian service is provided, two sequential activations of the interval advance input shall be required to advance through a Green interval, the first actuation shall terminate the WALK interval, and the second shall terminate the Green interval including the Pedestrian Clearance Interval.

Auxiliary Functions

General - The controller shall accommodate auxiliary functions in order to perform functions previously required in this specification or as hereafter described.

Stop Timing - Suitable input from auxiliary equipment or other external sources, shall cause cessation of controller timing during assertion of such input. Upon removal of

such input assertion, the interrupted interval which was timing shall resume normal timing.

Pedestrian Interval Timing - WALK and Pedestrian Clearance timing controls with the range of settings specified in Basic Interval Setting and Functions above, shall be provided for all phases of an individual controller.

Volume Density Timing - Variable initial and time waiting gap reduction timing controls with the range of settings specified in Basic Interval Setting and Functions above, shall be provided for all phases of an individual controller when specified on the bid sheet.

All-Red Timing - All Red timing controls with the range of setting specified in Basic Interval Setting and Functions above, shall be provided for all phases.

Preemption

General - When specified in the Plans, internal preemption to provide special preemption sequence shall be required. Activation may be from railroad track circuits, emergency vehicle preemption, mass transit equipment, supervisory control digital computer, or similar devices which may connect through a master controller or directly to the controller. Each controller shall have a minimum of 6 preempts.

Setting of Intervals and Functions - Means shall be provided for the setting of each preemption interval and/or function by means of a keyboard entry. Timing controls shall be calibrated in seconds. A clear visual indication of the value of each interval or function shall be given.

Constancy of Intervals - Constancy of intervals shall be in accordance with the tolerance specified previously in these specifications.

Continuation of Preemption Sequence - Once the preemption sequence is begun, it shall continue through the entire preemption cycle regardless of the condition of the preemption circuit switch.

Return to Normal Operation - When the preemption cycle has been terminated and the controller has returned to its normal conditions, the controller shall go through its normal interval sequence, as indicated by the sequence as if calls had been received and remembered on all phases.

Preemption Test Switch - A momentary contact switch shall be installed in the preemtor actuation circuit to provide a means to test the preemtor operation.

Circuit Design - No external preemtor shall be allowed.

Environmental and Testing

Minimum Requirements - Environmental and Test Procedures shall apply to the controller cabinet, controller unit, load switches, signal conflict monitor preemption unit, line filters, and flashers.

Environmental and Operating - The equipment shall fulfill or exceed the environmental and operating requirements as described in "Environmental and Operating Standards", NEMA Traffic Control Systems Standards, latest revision.

Testing - The equipment shall fulfill or exceed the testing requirements as described in "Test Procedures", NEMA Traffic Control Systems Standards, latest revision.

Certification - Each supplier shall submit with his bid a certification from an independent testing laboratory indicating that each type of equipment he intends to supply has undergone the above NEMA test requirements, and the equipment fulfills or exceeds all the NEMA environmental and operating standards.

Cabinet

Basic Construction - The controller and all associated equipment shall be provided in a weatherproof metal cabinet of clean-cut design and appearance. All exposed edges shall be free of burns and pit marks. The left wall of the cabinet shall be left open for future expansion.

Construction Material - The cabinet shall be constructed of ASTM designation B-209 sheet aluminum alloy 5052, with a minimum thickness of 3.175 mm (0.125 inches). The cabinet shall have a smooth natural aluminum finish. Handles and locks shall be rust proof.

Welds - All welds shall be neatly formed and free of cracks, blow holes, and other irregularities. All welds shall be made by the Heliarc welding method. Welds on exterior faces of the cabinet shall be flush.

Doors and Locks

General - All cabinets shall be provided with a hinged, rain tight and dust tight main door which shall encompass at least 80 percent of the full area of the cabinet front.

Lock - The main cabinet door shall have a #2 lock. Two keys shall be supplied for each cabinet and shall be shipped to the Signal Maintenance Supervisor, Department of Engineering, 1025 Elm Street, Knoxville, Tennessee 37921 on or before the date of delivery of the cabinets.

Gasket - A neoprene gasket shall be used to seal the main cabinet door.

Hinges - Hinges shall be made of 14 gauge stainless steel. A 6 mm (0.250 inch) diameter minimum stainless steel hinge pin is required.

Door Stop - All cabinets shall be furnished with a two-position door stop which shall hold the main door open at approximately 90 and 180 degrees. The door stop shall be designed to lock into position and withstand the force of a 48 KmPH (30 MPH) wind.

Locking System

Three Point System - A three point locking system shall be required and shall consist of the following security points:

- (a) Center of cabinet (lock);
- (b) Top of cabinet (operated by door handle); and
- (c) Bottom of cabinet (operated by door handle).

All related locking rod guides shall be welded in place on the inside of the cabinet door. The lock brackets shall be welded on the inside of the cabinet door.

Security Points - Security points (b) and (c) shall be designated so that they will remain in the locked position until the main cabinet lock is unlocked.

Door Handle - Door handle operation shall be such that the handle is vertical when in the locking position, and the opening motion shall swing the handle away from the location where the key is inserted. The handle shall be capable of being padlocked to prevent opening when padlocked.

Auxiliary (Police) Door

General - A small, hinged, and gasketed "door-in-door" or "police door" shall be included on the outside of the main controller door. The auxiliary door shall not allow access to the controller, its associated equipment, or exposed electrical terminals, but shall allow access to the small "Police" panel.

Materials - The police door shall be made of the material specified in the sections on "Construction Material" and "Gasket".

Lock - The police door shall be equipped with a lock whose key will not unlock the main door. Two keys shall be furnished for each cabinet and shall be shipped to the signal Maintenance Supervisor, Department of Engineering, 1025 Elm Street, Knoxville, Tennessee 37921 on or before the date of delivery of the cabinet.

Location - The police door shall be located in the top half of the main door for pad mounted cabinets and in the bottom half of the main door for pole mounted cabinets.

Police Panel

Material - The police panel may be either of cast aluminum or sheet aluminum.

Contents - The police panel shall contain the following:

Signal Head Power Switch - When in the OFF position, all power to the signal heads shall be removed.

Flash Switch - When in the ON position, the intersection shall flash as stipulated in previously for Flashing of Signals. A.C. power shall be removed from the load switches. Stop timing shall be applied to the controller.

Manual Switch - When in the ON position, the controller unit shall operate as specified previously for Manual Control. A complete on-off cycle of the manual push button shall cause immediate termination of the interval in process of timing, except for vehicle clearance intervals. All vehicle clearance intervals shall be timed by the controller unit. Activation of the manual push button shall not terminate vehicle clearance intervals until the controller unit has completely timed the preset clearance interval time.

Push Button Cord - Cabinets shall be wired for and shall include a manual push button cord, at least 2 meters (6 feet) in length to permit manual operations of the controller. The manual push button cord shall be a coiled type cord and electrical connection to the cabinet shall be hard wired. Electrical connection to the cabinet through a plug and jack shall not be permitted.

Special Events Switch - When in the ON position, the controller shall operate using the Maximum II time settings.

Mounting Shelves - Each cabinet shall contain at least three (3) adjustable shelves to accommodate mounting of the controller and all included auxiliary equipment. The shelves shall permit the controller and/or auxiliary equipment to be withdrawn from the cabinet for inspection or maintenance without breaking any electrical connections or interrupting operation of the controller. The range of adjustability shall be the full height of the cabinet in maximum increments of 50 mm (two inches).

Mounting Screws - Screws used for mounting shelves or adjustable shelf mounts shall not protrude beyond the outside wall of the cabinet.

Manufacturer's Identification - The manufacturer's name shall not appear on the outside of the cabinet, but shall appear on the inside of the cabinet door, with the year and month of manufacture. This can be done by a plate welded to the door, or by a moisture resistance label (or other approved methods). All cabinets shall have an identification plate molded or riveted on the outside of the cabinet door. The plate shall have a legend in 12 to 25 mm (1/2 to one inch) high letters identifying it to be traffic control equipment. The exact legend shall be subject to approval by the City of Knoxville.

Size and Mounting

Size

Minimum Outside Dimensions - The cabinets shall be of the following minimum dimensions: Base mount "M", pole mount "M", or base mount "P". In all cases, the cabinet shall be of adequate dimensions to properly house the controller, conflict monitor, detector amplifiers, and all relate communications interface panels, connectors and harnesses.

Pad Mounting - The cabinets shall be arranged and equipped for base mounting on a concrete foundation. An anchor bolt template, galvanized anchor bolts, nuts, and hardware as required for base mounting shall be furnished with each cabinet. These mounting materials shall be furnished within 60 days of purchase order issue.

Pole Mounting - The cabinets shall be arranged and equipped for mounting on a wooden or galvanized steel pole. Two double contact point mounting brackets shall be provided. Each mounting bracket shall have contact points a minimum of 100 mm (4 inches) apart and permit banding to pole. All brackets shall be galvanized.

Ventilation

Vents - The cabinet shall contain suitably designed, rain tight vents on the door of the cabinet. Vents shall allow the release of excessive heat and/or any explosive gases which might enter the cabinet. Vents shall have adequate opening area to permit the proper flow of air drawn by the vent fan. The intake vent shall be designed so that no water will be drawn into the cabinet. The intake and exhaust vents shall be located such as to provide for maximum passage of air around and over the equipment contained therein.

Filters - A removable dust filter shall be mounted on the inside of the main door completely covering the intake vent. The cabinet air filter shall be of the throw-away

type and its minimum area shall be 0.160 square meters (250 square inches). The filter shall be installed, positioned and firmly held in place so that all intake air is filtered with no by-passing permitted through cracks, clearance spaces or gaps. Positive retainment shall be provided on all sides to prevent warpage of the filter and prevent the entry of foreign matter around the edges.

Vent Fan - All cabinets shall have a thermostat controlled exhaust fan with safety screw located at the top of the cabinet. The exhaust fan shall have a minimum rating of 2.8 cubic meters per minute (100 C.F.M). The fan shall be rated for continuous duty and a lifetime of at least three years. A standard fuse of sufficient rating shall be used to protect against surges and short circuits.

Thermostat - The thermostat controlling the exhaust fan shall be manually adjustable to turn on between 32°C and 65°C (90°F and 150°F) with a differential of not more than 6°C (10°F) between automatic turn-on and turn-off.

Service Switches - Service switches shall be required for all cabinets.

Location - The service switches shall be located on the inside back of the main door and labeled as to their function.

Toggle Switches

Signal Head Power Switch - When in the OFF position, all power to the signal heads shall be removed.

Flash Switch - When in the ON position, the intersection shall flash as follows:

4 Phase - Yellow Phase 2, all others red

8 Phase - Yellow Phase 2 and 6, all others red

A.C. Power shall be removed from only the load switches.

Power ON-OFF Switch - When in the OFF position, A.C. power shall be removed from all circuits of the controller assembly except for the duplex receptacle and cabinet light.

Detector Call Switches - Each controller cabinet shall be equipped with an adequate number of vehicle loop detector switches and pedestrian call switches. These switches shall be capable of placing no call, continuous call, or pulse call.

Stop Timing Switch - When in the ON position, the controller shall stop timing.

Receptacle and Cabinet Light

Receptacle - A three (3) wire 115 VAC GFI duplex receptacle shall be mounted and wired in the cabinet. The receptacle shall be fed through a circuit breaker serving only the receptacle and the cabinet light and shall remain in service even when the power switch is turned off.

Cabinet Light - All cabinets shall be provided with a minimum of a 20 watt fluorescent fixture with bulb mounted in the top of the cabinet. A refrigerator door type switch shall be provided to turn the light on and off when the cabinet door is opened and closed.

Indicator Display - A door switch shall be provided to turn controller displays off when the door is closed.

Connecting Cables, Wiring and Panels

General

Requirements - The wiring in the cabinets shall conform to applicable requirements of the National Electrical Code (NEC), NEMA and all specifications contained herein.

Appearance - All wiring shall be neat and firm. Wires shall be neatly laced into cables with nylon lacing or nylon tie wraps. Cables shall be secured with nylon cable clamps. All cable clamps shall be fastened to the cabinet by screws.

Arrangement of Wires - The controller equipment and terminals shall be so arranged within the cabinet that they will not conflict with the entrance, training, and connection of the incoming conductors, and will be easily traceable and without entanglement. All terminal strips and load switches for field wiring shall be exposed for test purposes or maintenance without removal of the controller or its related equipment.

Standard Wiring - MS connectors and wiring harness for the controller unit, conflict monitor and external logic units shall be furnished and wired into the cabinet. All usable inputs and outputs shall be wired and terminated at a terminal strip. All wires shall be permanently identified.

Wire Size and Type - All conductors which are subject to flexing during the opening of cabinet doors, or the removal of equipment shall be stranded with a minimum of 19 strands. All conductors used in the controller cabinet shall be #22 AWG or larger, and shall conform at least to Military Specification: MIL-W-16878D, Type B or D, Vinyl - Nylon jacket, 600 Volt, 105 Degrees C. Conductors used in controller cabinets shall conform to the following color codes: AC - neutral = white; AC+ line = black; Safety Ground = green. Safety ground is to be electrically isolated from AC - neutral.

Wire Length - All wires shall be proper length before assembly. No wire shall be doubled back to take up excessive length.

Insulation - The wire and insulation shall be adequate to handle the current and voltage used in the cabinet.

Type 1 (Four Phase) Controllers - Cabinets for four phase controllers shall be wired and shall have the necessary logic to provide two internally generated vehicle overlaps and two pedestrian movements with the capability of being assigned some combination of phases at a future date by the simple addition of wire jumpers.

Type 2 (Eight Phase) Controllers - Cabinets for eight phase controllers shall be wired and have the necessary logic to provide eight vehicle movements and four pedestrian movements with capability of being assigned some combination of phases at a future date by simple addition of wire jumpers.

Connecting Cables - Electrical connections from the controller and auxiliary devices to outgoing and incoming circuits shall be made in such a manner that the controller and/or auxiliary devices can be replaced with a similar unit, without the necessity of disconnecting and reconnecting the individual wire leading therefrom. This shall be accomplished by means of MS connectors and other approved NEMA standard connectors using the NEMA standard pin assignments.

Terminals

General - Terminals shall be provided, as a minimum, for the following:

- (a) Terminal with circuit breaker with an internal power line switch for the incoming power line;
- (b) Terminal, unfused, for the neutral side of the incoming power line;
- (c) Terminals and bases for signal load switches and outgoing signal field circuits;
- (d) Terminals and bases for signal flasher and outgoing signal field circuits;
- (e) Terminals for detector cables;
- (f) Terminals for all required auxiliary equipment; and
- (g) Communications panel for future system communications.

Clearance Between Terminals - Adequate electrical clearance shall be provided between terminal strips. The controller and auxiliary equipment, panel(s), terminals and other accessories shall be so arranged within the cabinet that they will facilitate the entrance and connection of incoming conductors.

Soldering - Soldering of conductors to terminal lugs may be omitted provided a calibrated ratchet type crimping tool is used.

Use of Terminal Strips - All input and output circuit connections to the controller unit, conflict monitor, external logic units, load switches, loop detectors, coordination units, and all other auxiliary equipment shall be made by the use of terminal strips.

Terminal Strips - Terminal strips shall be provided for connecting the field wires to the output of the load switches. Terminal strips shall be included in cabinets to permit connecting a minimum of 48 field wires (four (4) terminal strips) and loop detector wires (four (4) terminal strips) which shall include wiring for AC+ and AC-. Terminal strips shall be provided for connecting the controller outputs to the load switches. A minimum of one hundred (100) terminals shall be provided for future interconnect and coordination purposes.

Labels - All terminal strips shall have their connections numbered. A wiring chart shall be provided on the inside of the main cabinet door, to identify the connections of the terminal strips. It shall be completely legible.

Signal Circuit Polarity - The outgoing signal circuits shall be of the same polarity as the line side of the power service; the common return of the same polarity as the grounded side of the power service.

Ground Bus Bar

Location - A copper ground bus bar shall be mounted on the side of the cabinet wall for the connection of A.C. neutral wires and chassis ground wires. It shall be securely fastened to the cabinet.

Multiple Bus Bars - If more than one (1) ground bus bar is used in a cabinet, a minimum of a No. 10 AWG copper wire shall be used to interconnect them.

Ground Wire Attachment - Each bus bar shall have at least two (2) positions where a No. 6 AWG stranded copper wire can be attached.

Circuit breakers - All cabinets shall be furnished with a minimum of three (3) circuit breakers. A 15 amp breaker shall control the duplex outlet and the service lamp, a 30 amp circuit breaker shall control all other electrical connections and a 5 amp system equipment breaker.

Fusing and Surge Protection

General - All lightning arrestors and surge protectors shall be easily accessible from the front of the panel.

AC Service Input - Each controller cabinet shall be furnished with an EDCO SPA-300-10 surge protector or an approved equal on the AC Service Input.

Vehicle Loop Detector Inputs - Each vehicle loop detector input shall be protected with an EDCO SRA-16 surge protector or an approved equal. Each type 1 and Type 2 controller cabinet shall be equipped with protection for a minimum of four (4) and six (6) vehicle loop detector inputs respectively. Remote vehicle detector inputs shall be protected with an EDCO SRA-63 surge protector or an approved equal. Each controller cabinet shall be equipped with protection for a minimum of three (3) remote vehicle detector inputs.

Field Wire Terminals - Each load switch output terminal as it enters the cabinet shall be protected with a TII 317-B arrestor or an approved equal. Twelve arrestors will be required in Type 1 cabinets and eighteen arrestors will be required in Type 2 cabinets.

Pedestrian Detector Inputs - Each pedestrian push button detector input shall be protected with an EDCO SRA-63 surge protector or an approved equal.

Preemption Inputs - Each preemption input shall be protected with an EDCO SPA-60A surge protector or an approved equal.

Radio Interference - A radio interference suppressor shall be provided in a series with AC power before it is distributed to any equipment inside the cabinet. The filter shall provide a minimum attenuation of 40 decibels, and a frequency range of 200 kilohertz to 60 megahertz. It shall be hermetically sealed in a metal case. The filter shall have the same minimum circuit rating as the main circuit breaker and shall meet the standards of the Underwriter's Laboratories, Incorporated and Electronic Industries Association.

Cabinet Equipment Noise

AC Coils - The manufacturer shall provide cabinet noise suppression as required by the particular controller.

Other - The thermostat contact and vent fan shall be properly suppressed.

Cabinet Documentation

General - Each cabinet shall be furnished with three (3) copies of the cabinet wiring diagram. These prints shall be full size and completely legible. Where possible, diagrams shall be to a scale picture image of the cabinet layout.

Minimum Requirements of Wiring Diagrams

Wiring - Diagrams shall show the complete wiring of all cabinet components, all switches, terminal board connections, connector connections, fan connections, light fixture connections, flash transfer relays, lightening

arrestors, surge protectors, load switch panels, terminals, and any other control functions. Each item shall be clearly identified as to its function.

Components - All components in the cabinet shall be located according to their function and in such manner that they may easily be found on the wiring diagram.

Sequence Diagrams - The supplier shall make provisions for the mounting of a sequence diagram inside the main door for trouble-shooting purposes. The mounting technique shall provide for the diagram to be completely legible, waterproof, and tightly affixed to the door.

Storage Pouch - A clear plastic pouch approximately 250 X 350 mm (10" X 14") with a zip lock shall be provided for each controller. The pouch shall not be mounted inside the controller cabinet, but shall be loose for placement inside the controller cabinet wherever the City desires.

Subsection 730.26 and substitute the following:

730.26 - Traffic Actuated Controllers. It is the purpose of this section of the specification to set forth minimum design and operating requirements for multi-phase (four and eight phase) traffic actuated traffic signal controllers.

General Design Requirements

Specification Requirements - The General Design Requirements in these specifications shall apply in addition to certain design, operational, and functional requirements hereinafter described.

NEMA Design Requirements - The controller shall be designed in accordance with the applicable requirements included in NEMA Traffic Control Systems Standards, latest revision.

Manufacturer - All controllers supplied under these specifications shall be manufactured by the same manufacturer.

Controller Interchangeability - Interchangeability of controllers furnished under this specification shall be achieved by connector plug interchangeability as designated in NEMA Traffic Control System Standards, latest revision.

Controller Expansibility - All controllers shall be 8 phase and shall contain time base coordination modules to communicate with an on street master and a central control area. The controller shall have the ability to request a data download from the central control area in the absence of a control operator.

Operational Requirements

Mode of Operation - The controller shall provide the multi-phase operation described previously in the specifications and shall be fully actuated with means for receiving actuations in all phases.

Call to Non-Actuated Mode - The controller shall feature an input which, when asserted, shall permit the selection of non-actuated mode of operation on any of its phases.

Operation with Auxiliary Functions/Devices - The controller shall be capable of having its basic operation expanded or augmented by the addition of auxiliary functions of devices as described in the General design requirements.

Minimum Green

Actuated Phase - The minimum green shall consist of an initial portion only or a separately set Minimum Green function. If pedestrian functions are provided and a pedestrian actuation is received, the minimum green shall consist of a WALK interval plus a Pedestrian-Clearance interval.

Non-Actuated Phase - In the non-actuated mode of operation, the minimum green on the non-actuated phase shall be equal to the values described in Actuated Phases described above or shall be equal to a separately set Minimum Green function.

Unit Extension - The actuation of a vehicle detector during the extendible portion of an actuated traffic phase having the right-of-way shall cause the retention of right-of-way by that traffic phase for one Unit Extension portion from the end of the actuation but subject to the Maximum (extension limit).

Maximum (Extension Limit) - The Maximum or extension limit shall determine the maximum duration of time the right-of-way can be extended for a phase having successive detector actuations spaced less than a Unit Extension portion apart.

Initiation of Maximum (Extension Limit) - The timing of the Maximum or extension limit shall commence (1) with the first actuation or other demand for right-of-way on a traffic phase not having the right-of-way or (2) at the beginning of the Green interval if an actuation or other demand for right-of-way has been previously registered on a traffic phase not having the right-of-way.

Transfer of Right-of-Way

Conditions - The actuation of any detector on a traffic phase not having the right-of-way shall causes the transfer of the right-of-way to that traffic phase at the next opportunity in the normal phase sequence provided that there has been an expiration of a Unit Extension portion with no continuing actuation or an expiration of the Maximum (extension limit) timing on the proceeding phase having the right-of-way.

Simultaneous Yield - When transferring the right-of-way from the major street to the minor street, or vice versa (i.e., across the barrier), both phases shall yield the right-of-way simultaneously, regardless of which phase was last to find a gap in excess of the allowable gap or to have the Maximum (extension limit) terminate. The phase that first finds a gap or terminates its maximum green interval shall remain in the green interval until the other phase also finds a gap in excess of the allowable gap or terminates its maximum green interval.

Pedestrian Interval - When a pedestrian interval is timing, transfer of right-of-way shall not take place during the walk or clearance interval. Transfer of the right-of-way shall take place only during the DON'T WALK interval.

Change Clearance Interval(s) Prior to Transfer - The transfer of right-of-way to any conflicting phase shall occur only after the display of the appropriate change clearance interval(s).

Rest in Absence of Actuation

Minimum Rest - In the absence of detector actuation or assertion of recall functions, the right-of-way indication shall remain (rest) on the traffic phase on which the last actuation occurred.

Rest in All Red - When programmed, in the absence of detector actuation or assertion of recall switch(es), the controller, after display of the appropriate clearance interval(s) on the last phase having the right-of-way, shall rest in Red (and associated Pedestrian DON'T WALK indications) on all phases until detector actuations are received.

Memory Feature - Unless precluded by the operation of non-memory feature, the following memory retention shall be provided in the controller.

Memory During Change Clearance Interval(s) - An actuation received during a change clearance interval for a traffic phase shall cause the right-of-way to return to that phase at the next opportunity in the normal phase sequence.

Memory if Phase Terminated by Maximum (Extension Limit) - If the right-of-way is transferred by the operation of the Maximum or extension limit, the traffic phase losing the right-of-way shall again receive it without further actuation at the next opportunity in the normal phase sequence.

Memory if Phase Terminated by Unexpired Unit Extension - If right-of-way is transferred at a time less than one Unit Extension after a vehicle actuation, the traffic phase losing the right-of-way shall again receive it without further actuation at the next opportunity in the normal phase sequence.

Pedestrian Timing Operation - The following pedestrian function operation shall be provided.

Pedestrian Timing with Non-Actuated Phase - In the non-actuated mode of operation, a WALK interval shall be provided simultaneously with the associated Minimum Green interval of the non-actuated phase. A flashing DON'T WALK Pedestrian Clearance interval shall follow the WALK interval, during which the Green traffic phase continues to be displayed.

Pedestrian Timing with Actuated Phase - When pedestrian actuation is received, a WALK interval shall be provided concurrently with the associated Green traffic phase interval. A flashing DON'T WALK Pedestrian clearance interval shall follow the WALK interval during which the Green traffic phase continues to be displayed.

Condition in Absence of Pedestrian Call - In the absence of pedestrian actuation or assertion of pedestrian recall functions, pedestrian signals shall remain in a DON'T WALK condition.

Recycle of Pedestrian Functions - In the absence of opposing phase demand, it shall be possible to recycle the pedestrian interval functions to succeeding pedestrian actuations without change in vehicle indications.

Pedestrian Actuation Memory - Pedestrian actuations received by a phase during steady of flashing DON'T WALK indications of that phase shall be remembered and shall cause the controller to provide pedestrian timing functions for that phase at the next opportunity in the normal phase sequence.

Non-Extension of Pedestrian Intervals - Successive pedestrian actuations shall not cause extension of the pedestrian intervals.

NEMA Operational Requirements - In addition to the basic operational requirements specified above, the controller shall provide the operational features for the applicable configuration included in the NEMA Traffic Control Systems Standards, latest revision.

Functional Requirements

Basic Functional Requirements - Functional requirements for the multi-phase traffic actuated controller shall be as specified in the General Design Requirements in Section 2 of these specifications.

NEMA Functional Requirements - In addition to the above, the controller shall provide the functional features for the applicable configuration, included in the NEMA Traffic Control Systems Standards, latest revision.

Overlaps - Overlaps shall be provided as an internal function to the controller. All controllers shall provide a minimum of four (4) overlaps. Overlap assignments shall be made using the industry standard interchangeable NEMA Overlap card described in the NEMA Traffic Control Systems Standards, latest revision. The overlap card shall be removable from the front of the controller without removing any modules or covers.

Delete Subsection 730.30 and substitute the following:

730.30 - Coordination. The controller shall contain communications and time base coordination modules to communicate with an on street master and a central control area. The local controller shall have the ability to request a data download from the central control area in the absence of a control operator. The coordinator shall have a minimum of 6 cycle lengths, 5 offsets, and 16 split selections.

Force-Off Feature - The controller shall contain a Force-off feature which, when asserted shall cause termination of the current phase provided that phase is in the extension portion. In no case shall assertion of force-off cause termination in a clearance interval, or during a minimum green for vehicles or pedestrians.

NEMA Coordination Requirements - In addition to the minimum coordination requirements specified above, the controller shall use the appropriate pin designations for CNA (Call to Non-Activated), Hold, and Force-Off as outlined in NEMA Traffic Control Systems Standards, latest revision.

On Street Master - An on street master capable of automatic and requested controller failures, detector failures, and communications failures shall be furnished when required. The on street master shall be housed on a local cabinet of the "P" type and size and shall

include all side panels, dial up modem, harnesses and connectors to provide a complete and operable system.

Functional Requirements - The on street master shall poll each interconnected local intersection at a maximum of every 3.5 seconds through the use of a modem and standard phone line to the central control area.

Operational Requirements - The on street master shall contain the following operational features:

1. The ability to call the central control area and request a data download in the absence of a control operator.
2. Directs up to 30 local intersections to implement selected timing patterns.
3. Store a library of 360 patterns.
4. Monitors system for proper operation and notifies the central control area of conditions found.
5. provide output data from 48 system sampling sensors.

System Interconnect Cable - The on street master shall be connected to each local intersection through an approved shielded, 6 pair twisted, communications grade cable. There shall be no external splices in the cable outside of each local control cabinet. There shall be a 30 day test period before final acceptance will be made to ensure integrity of communications cable and system operation. The cable pairs shall be identified and follow the same color code used currently by the City of Knoxville.