alignment of the slot. The blade used for the saw cut shall provide a a clean, straight, well-defined saw cut of the width and depth indicated in the Plans without damage to adjacent areas. Where the loop changes direction, the saw cuts shall be overlapped to provide full depth at all points of intersection.

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

2.18.3.2. Loop wire shall be installed in the slot using a dull edge wooden paddle or wheel to prevent damage to the loop jacket. Conductors of each loop shall be run continuously from the nearest pull box with no splices permitted. All loops shall be wound in the same direction with the start and end of each clearly marked with a permanent label at the pull box. The loop conductors running from the loop to the adjacent pull box shall be twisted a minimum of 10 turns per meter. In addition, each loop conductor shall be permanently identified by the loop number shown in the Plans. Paired loops shall be joined in the pull box in series or parallel so that optimum sensitivity as recommended by the detector manufacturer is obtained at the sensor unit.

2.18.3.3. After the conductors are installed in the slots, the loops shall be tested for continuity and shorts with a meg-ohm-meter set at 500 Volts. Any defective wire shall be replaced. After testing, the slots shall be filled with an approved loop sealant to within 3 mm of the pavement surface. Before setting, surplus sealant shall be removed from the adjacent road surfaces without the use of solvents.

2.18.4. The Contractor may, at his own expense, use approved pre-formed loops instead of saw cut loops.

2.18.5. The loop conductors for each loop shall be spliced in the pull box to a detector lead-in cable in accordance with section 2.16.1.J of these specifications. The detector lead-in cable shall run continuously from the pull box to the field terminal in the cabinet with no splices permitted.

2.19. **SIGNS.**

2.19.1. OVERHEAD STREET NAME SIGNS. Street name signs shall be installed on mast arms after all other loads are applied to the mast arm. The signs shall be located in accordance with the plan details. Signs shall be mounted so that the legend is level. The final location shall be determined by the Engineer.

2.19.1.1. Installation of signs on mast arms shall be accomplished with suitable stainless steel banding, clamps, and brackets capable of withstanding 160 Km/h winds. Street name signs over 450 mm in height shall be installed using approved sign mounting brackets as shown in the Plans. All bolts inserted through sign faces shall have flat fiber washers installed between the reflective sheeting and bolt heads. Bolt holes in signs shall be drilled in the field

2.19.2. REGULATORY SIGNS. The R10-Series signs shall be mounted on the mast arm to the right of the left turn signal head using an approved sign mounting bracket as shown in the traffic signal installation details.

2.19.3. PEDESTRIAN PUSH-BUTTON SIGNS. Pedestrian push-button signs shall be mounted to the traffic signal pole above the appropriate pedestrian push-button. Mounting shall be accomplished using suitable stainless steel banding, clamps and brackets capable of withstanding 160 Km/h winds. As an alternative, the pedestrian sign mounting bracket may be constructed integral to the pedestrian push-button assembly.

2.20. **PEDESTRIAN PUSH-BUTTONS.** Pedestrian push-buttons shall be installed on the poles or pedestals indicated in the Plans. They shall be installed at a height of 1m above the adjacent sidewalk (or ground if no sidewalk is present). The push-button shall be located on the side of pole nearest the pedestrian walkway, and perpendicular to the intended crossing direction.

2.21. **TRAFFIC SIGNAL TURN-ON.**

2.21.1. FLASHING OPERATION. At locations without previous traffic signal control, the new traffic signals shall be flashed 2 to 3 business days prior to full signal system turn-on.

2.21.2. SYSTEM TURN-ON. The signal system turn-on shall not occur on Fridays, weekends, or holidays and shall be completed prior to 3:00 p.m. on the day of the turn-on.

2.21.3. SUPPLIER REPRESENTATIVE. The supplier of control equipment shall have a representative present at the signal system turn-on.

2.21.4. TRAFFIC ENGINEERING NOTIFICATION. The Bureau of Traffic Engineering shall be notified at least one week in advance of the date of signal turn-on.

2.22. **TEST PERIOD.** Following completion of all electrical apparatus hook-ups and the system turn-on, the signals shall operate satisfactorily for 30 days under normal operation prior to acceptance by the State. During the test period, the signals shall operate trouble-free with no major failures of the controller or its components. Should any defect develop under normal and proper operating conditions during the testing period and prior to acceptance by the State, this malfunction shall be corrected by and at the expense of the Contractor, including all labor, materials and associated costs. Minor failures such as lamp failures or loop detector re-tuning will not be the basis for starting a new test period, provided the failures are repaired immediately and the same failures do not recur during the remainder of the test period. A major malfunction or failure of the controller and its components will result in a new 30 day test period being implemented after the repairs have been made.

2.23. **GUARANTEE.** All equipment furnished on a project by the Contractor shall be guaranteed against any imperfections in workmanship and materials. The customary manufacturers' warranties shall be assigned to the Maintaining Agency.

2.24. **MANUALS.** A minimum of 2 manuals shall be provided for each controller and shall include complete nomenclature, wiring diagrams, schematics showing test voltages, functional description of circuits, parts list and cross reference to standard part numbers, appropriate testing procedures, and other pertinent data.

3. MATERIALS.

3.1. **DESCRIPTION.** These specifications cover the general materials and miscellaneous hardware for the installation of a traffic signal to be constructed in accordance with and at locations indicated in the contract, shown in the Plans or designated by the Engineer.

3.2. **MATERIAL REQUIREMENTS.**

3.2.1. **GENERAL.** All materials used in the fabrication or assembly of the items listed below shall be new, shall be of the best quality and workmanship, shall be the best standard product of a manufacturer regularly engaged in the production of this type of equipment and shall be of the manufacturer's latest approved design. Major items of electronic equipment installed under this contract shall be of the same type and consist of products supplied by the same supplier in order to secure uniformity, single responsibility, and most satisfactory service.

3.2.1.1. The traffic signal shall be complete, and the Contractor shall furnish and install all equipment necessary for the satisfactory operation of the signal system whether specifically mentioned or not.

3.2.2. **N.E.M.A. TRAFFIC CONTROLLER ASSEMBLY.**

3.2.2.1. **GENERAL.** The N.E.M.A. Traffic Controller Assembly shall meet the requirements of the N.E.M.A. Standards Publication No. TS 2-1992. The N.E.M.A. traffic controller assembly shall be either pole mounted or pad mounted. The specific requirements of each type are listed below.

3.2.2.2. **CONTROLLER UNIT.** The controller unit shall meet the requirements of a Type 1A per Section 3 of the N.E.M.A. Standards

3.2.2.3. **MALFUNCTION MANAGEMENT UNIT.** The malfunction management unit shall meet the requirements of Section 4 of the N.E.M.A. Standards.

3.2.2.4. **TERMINALS AND FACILITIES.** The controller assemblies' terminals and facilities shall, as a minimum, meet the requirements of Section 5 of the N.E.M.A. Standards.

3.2.2.4.1. POLE MOUNTED CONTROLLER ASSEMBLIES. The pole mounted controller assemblies shall, as a minimum, be equipped with wired sockets and bus interface units of the quantities listed for Configuration 2 of Table 5.3.1-1 of the N.E.M.A. Standards.

3.2.2.4.2. PAD MOUNTED CONTROLLER ASSEMBLIES. The pad mounted controller assemblies shall be classified as either Type I or Type II. Type I pad mounted controller assemblies shall be equipped the same as pole mounted controller assemblies. Type II pad mounted controller assemblies shall, as a minimum, be equipped with wired sockets and bus interface units of the quantities listed for Configuration 4 of Table 5.3.1-1 of the N.E.M.A. Standards. If the Plans require more than 16 channels of detection, then additional detector racks of Type 2 configuration shall be added to provide the necessary detector slots.

3.2.2.4.3. AC SERVICE TRANSIENT PROTECTION. The AC service transient protection shall be accomplished by a solid state hybrid filtering surge protector meeting the surge requirements of Section 5.4.2.4 of the N.E.M.A. Standards, except that it shall have a clamp voltage of 250 Volts and be designed to absorb power line noises in the range of 10 kilohertz to 20 megahertz.

3.2.2.4.4. LIGHTING FIXTURE. The light fixture shall be flourescent, and provided with an appropriate flourescent lamp.

3.2.2.4.5. LIGHTING FIXTURE SWITCH. The light switch shall be door actuated.

3.2.2.4.6. POLICE COMPARTMENT SWITCHES. The panel behind the police door shall contain 2 switches to accomplish the following functions: (1) change from normal operation to flashing, and vice versa and (2) interrupt power to the signal heads.

3.2.2.5. **AUXILIARY DEVICES.** The auxiliary plug-in devices shall, as a minimum, meet the requirements of Section 6 of the N.E.M.A. Standards.

3.2.2.5.1. THREE-CIRCUIT SOLID STATE LOAD SWITCHES. The load switches shall meet the requirements of Section 6.2 of the N.E.M.A.

3.2.2.5.2. SOLID STATE FLASHERS. The flashers shall meet the requirements of Section 6.3 of the N.E.M.A. Standards. Standards.

3.2.2.5.3. FLASH TRANSFER RELAYS. The flash transfer relays shall meet the requirements of Section 6.4 of the N.E.M.A. Standards.

3.2.2.5.4. INDUCTIVE LOOP DETECTORS. The inductive loop detectors shall, as a minimum, meet the requirements of Section 6.5 of the N.E.M.A. Standards.

3.2.2.6. **CABINETS.** The cabinets shall meet the requirements of Section 7 of the N.E.M.A. Standards, as modified below.

3.2.2.6.1. HOUSING. The cabinets shall be of unpainted sheet aluminum alloy construction.

3.2.2.6.2. POLE MOUNTED CONTROLLER ASSEMBLIES. The pole mounted controller cabinet shall be size 4 per Table 7.3-1 of the N.E.M.A. Standards. The cabinet shall have a continuously welded bottom of the same material as the rest of the cabinet.

3.2.2.6.3. PAD MOUNTED CONTROLLER ASSEMBLIES. Type I pad mounted controller assembly cabinets shall be size 5 per Table 7.3-1 of the N.E.M.A. Standards. Type II pad mounted controller assembly cabinets shall be size 6 per Table 7.3-1 of the N.E.M.A. Standards.

3.2.2.7. **BUS INTERFACE UNIT.** The bus interface units shall meet the requirements of Section 8 of the N.E.M.A. Standards.

3.2.3. **TYPE 170E TRAFFIC SIGNAL CONTROL SYSTEM**

3.2.3.1. **GENERAL.** The Type 170E traffic signal control system shall, as a minimum, meet the State of California Traffic Signal Control Equipment Specifications (TSCES), dated January 1989, as modified by TSCES Addendum 8, dated November 1993, and Addendum 4 dated July 1991 with the additions or modifications as shown in the following specifications.

3.2.3.2. **RESPONSIBLE PARTIES.** Any reference to the State, State of California, or Agency shall mean the local agency responsible for maintaining the traffic signal. Any reference to the Contractor shall mean equipment manufacturer or supplier.

3.2.3.3. **TESTING MANUALS.** Two manuals containing the flow chart, listing, and instructions of the test program shall be furnished to the agency responsible for maintaining the traffic signal when the controller unit is delivered.

3.2.3.4. **CABINETS.** The pole mounted cabinets shall be Model 336A, and the pad mounted cabinets shall be Model 332B meeting the requirements of Chapter 6 of the TSCES with the following additions or modifications.

3.2.3.4.1. FINISH. The cabinet finish shall be natural aluminum.

3.2.3.4.2. LIFT EYES. The cabinet lift eyes shall be removable so that they can be turned down after installation of the cabinet.

3.2.3.4.3. LIGHT FIXTURES. Cabinets shall be furnished with fluorescent light fixtures, including lamps, over the front and back doors that are controlled by door-activated switches.

3.2.3.4.4. PLAN DRAWER/WORK SURFACE. A drawer shall be mounted in the EIA rack between the Controller and the top input file. It shall be mounted on sliding tracks having lockout and quick-disconnect features. The drawer shall be able to extend out 350 mm, and shall be capable of supporting a 18 kg load when fully extended. The drawer shall be provided with a hinged aluminum top covered with a chemical-proof Formica-type plastic sheet that can be lifted to gain access to the interior of the drawer. The interior of the drawer shall have nominal dimensions of 25 mm high, 330 mm deep, and 400 mm wide.

3.2.3.4.5. ADDITIONAL MODEL 336A REQUIREMENTS. The Model 336A cabinets shall be furnished with a continuously welded bottom of the same material as the rest of the cabinet, and all of the hardware necessary to permit mounting to a 300 mm outside diameter pole.

3.2.3.4.6. ADDITIONAL MODEL 332B REQUIREMENTS. The Model 332B cabinets shall be furnished with the power distribution assembly #2 in lieu of the power supply and power distribution #1 assemblies. The cabinets shall be supplied with the circuit breaker option per Section 6.4.3.9 of the TSCES. The cabinet shall be furnished with anchor bolts, nuts and washers.

3.2.3.4.7. ADDITIONAL OUTPUT FILE #1 REQUIREMENTS. The output file #1 supplied with the cabinet shall be modified to provide compatibility with the red monitoring features of the conflict monitor.

3.2.3.5. **CONTROLLER.** The controller unit shall be a Model 170E per Section 2 of the TSCES Addendum 8, dated November 19, 1993.

3.2.3.6. **PROGRAM MODULE.** The program module shall be a standard Model 412C as specified in Section 3 of the TSCES Addendum 8, dated November 19, 1993. The program module shall be provided with the latest version of the Wapiti Micro Systems W4IKS software.

3.2.3.7. **CONFLICT MONITOR.** The conflict monitor shall meet the requirements of a Model 210 per Chapter 4, Section 5 of the TSCES with the following additional monitoring functions: red monitoring; absence of signal on a channel; simultaneous multiple indications on a channel; program card ajar; power interrupt after failure; short or absence of yellow; AC line monitoring; full systems compatibility with Wapiti Microsystems Traffic Systems software.

3.2.3.8. **FLASHER.** The flasher shall meet the requirements of a Model 204 flasher per Chapter 3 of the TSCES.

3.2.3.9. **LOAD SWITCH.** The load switch shall have modular switches that can be easily replaced with the use of a screwdriver, and meet the requirements of a Model 200 switch pack per Chapter 3 of the TSCES.

3.2.3.10. **FLASH TRANSFER RELAYS.** The flash transfer relays shall be heavy duty relays meeting the requirements of the Model 430 per Section 6.4.6 of the TSCES.

3.2.3.11. **SURGE PROTECTOR.** The surge protector shall be a filtering surge protector that absorbs power line noise and switching transients, and provides lightning protection. It shall consist of three basic sub circuits: primary clamp, secondary clamp, and the filter. It shall be rated for a peak current of 20,000 amps from an 8 by 20 microsecond wave shape. The clamp voltage shall never exceed 280 volts during a peak surge. It shall provide a maximum of 10 amps continuous service current at 120 volts AC and 60 Herttz. It shall have an operating temperature range of -40 to +85 degrees Celsius. The filter shall be designed to absorb power line noises in the range of 10 kilohertz to 20 Megahertz.

3.2.3.12. **DC ISOLATOR.** The DC Isolator shall meet the requirements of a Model 242 two-channel DC Isolator per Chapter 5 of the TSCES.

3.2.3.13. **AC ISOLATOR.** When called for in the Plans, the AC Isolator shall meet the requirements of a Model 252 two-channel AC Isolator per Chapter 5 of the TSCES.

3.2.3.14. **DETECTOR.** The detector sensor units provided shall, as a minimum, meet the specifications given in Chapter 5 of the TSCES. In addition, the following features shall be included: thumb-wheel/push-wheel switch or push button switch to allow selection of a minimum of 8 pulse sensitivities, 7 presence levels and an "off" mode per channel; open loop test switch that displays previous faults on channel indicators while continuing to process and output valid detections; multiple channel sequential scanning; an inductance range of 20-2000 microhenries.

3.2.4. **SIGNAL HEADS.** All signal heads on a project shall be the product of one manufacturer with the exception of programmed visibility signal heads and one piece pedestrian signal indications. The signal heads shall be in general conformance with the latest edition of the Equipment and Materials Standards of the Institute of Transportation Engineers - Vehicle Traffic Control Signal Heads, and as specified below.

3.2.4.1. **STANDARD VEHICLE TRAFFIC SIGNAL HEADS.** The housing for each vehicle traffic signal section shall be made of a durable polycarbonate. The housing shall be yellow with black doors. The visors for each signal section shall be of the tunnel type, and be made of a durable black polycarbonate of not less than 2.5 mm in thickness. The reflectors shall be of either specular aluminum or metalized plastic. All lenses shall be 300 mm diameter glass.

3.2.4.1.1. ARROW LENSES. The arrow may be formed of either enamel baked or fired onto the glass lens, or an arrow shield placed behind the lens. The arrow shield shall only allow light through the arrow display, with no extraneous light around the edges.

3.2.4.2. **PEDESTRIAN TRAFFIC SIGNAL HEADS** The pedestrian traffic signal heads shall be of either two piece polycarbonate or one piece cast aluminum construction. The housing shall be yellow with black doors. The visors for each signal section of the two piece heads shall be of the tunnel type, and made of a durable black polycarbonate

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KANSAS DEPARTMENT OF TRANSPORTATION

TRAFFIC SIGNAL SPECIFICATIONS

TEI20BSI 04/28/98

FHWA APPROVAL	05/18/98		APP'D	Linda G. Voss, P.E.	
DESIGNED	J.F.F.	DETAILED	J.F.F.	QUANTITIES	TRACED
DESIGN CK.	D.A.C.	DETAIL CK.	D.A.C.	QUAN. CK.	TRACE CK.

Plotted By : J. Olson Thacher Bldg., 4th Floor
Plot File : I:\87\TEI20bsi
Plot Date : 7-12-99