STATE OF NEW JERSEY
DEPARTMENT OF TRANSPORTATION
TRENTON, NEW JERSEY 08625

METRIC SPECIFICATIONS FOR TRAFFIC CONTROLLER ASSEMBLY HARDWARE (EIGHT PHASE 170E TRAFFIC SIGNAL CONTROLLER ASSEMBLY)

N. J. Specification No. EBM-TSC-170E Effective Date: July 1, 2001

New Jersey Department of Transportation Specifications for a 170E Microprocessor Based, Eight Phase Controller Assembly with Internal Time Base Coordination, and associated test equipment.

The purpose of these specifications is to describe the minimum acceptable design and operating requirements of the hardware for a 170E microprocessor based, 8-phase dual ring, fully traffic actuated traffic signal controller assembly with internal time base coordination.

GENERAL - I

1-1 The traffic controller assembly shall consist of a digital controller unit, signal conflict monitor, input and output files, load switches, filters, flasher, relays, connection wiring harnesses and other miscellaneous equipment in a complete and fully wired aluminum weatherproof cabinet. Serial numbers with bar coding shall be engraved into the frame of the controller and all plug-in circuit boards. Controller modules and boards shall be permanently labeled with serial numbers that shall also be engraved into the frame of the controller.

1-2 The complete controller assembly shall conform to the CALTRANS requirements for 170E Controllers housed in 332 Cabinets, except as amended and supplemented hereinafter. The manufacturer must supply certification that they currently have an approved 170E and 332 Cabinet on the CALTRANS QPL (Qualified Products List).

1-3 Materials not specifically covered in these specifications shall be in accordance with the accepted standards of the National Electrical Manufacturers Association, The Underwriters Inc., The National Electrical Code, and the American Society for Testing and Materials.

1-4 Controller and Cabinet test equipment shall be supplied as subsequently defined.

CONTROLLER UNIT AND CONNECTORS - II

2-1 CALTRANS 170E Certification

The controller shall comply with all specifications for the CALTRANS 170E controller, except as amended herein. The supplier shall submit documentation verifying that the base unit is on the CALTRANS QPL (Qualified Products List).

2-2 LED Display Elimination

The standard 170 LED display and single keyboard shall be replaced with the Liquid Crystal Display and extended keyboard described in Subsections 2-3, 2-4, 2-5, and 2-6.

2-3 Front Panel Processor

The 170E controller shall include a front panel display which is controlled by a microprocessor. The microprocessor shall be a Motorola MC68HC11 or equivalent. The front panel processor board shall include the following memory system:

A. 32 kilobytes of EPROM (27256)

B. 16 kilobytes of RAM

C. 0.5 kilobytes of EEPROM

The front panel display shall also include an RS232 port. This port shall be internally connected to ACIA #3 of the 170E. In addition, the front panel processor shall be capable of receiving all port outputs of addresses $5008-500A (Normal Output Latches) and writing to port $5007 (Keyboard Latch) of the 170E memory system.

2-4 Liquid Crystal Display (LCD)

Liquid crystal displays shall be utilized. The display shall have a backlite for viewing at night. Incandescent indicator lights are not acceptable.

A. Size of Display

The display shall consist of a minimum of a 80 characters/line by 4 line display. As an alternative, dual 40 by 4 line displays can be provided.

B. Temperature Range

The LCD display shall be fully operable in the temperature range of -20 °C to +70 °C.

C. Contrast

The contrast of the display shall be controlled by a knob marked contrast on the front panel.

2-5 Extended Keyboard

A second 12-switch keypad, with mechanical characteristics similar to the primary one, shall be included in addition to the standard 16-switch keypad utilized on the 170E. The extended keypad shall as a minimum, include the following keys:

A. Four Arrow Keys

B. PGUP, PGDOWN, DISPLAY, MENU, Decimal

C. Three Special Function Keys

2-6 Front Panel Software

Upon start-up, the front panel processor shall emulate the operation of the normal 170E keyboard and display by utilizing the LCD display to display the information normally directed to the LED call lights and numeric characters. While in this mode, the remaining portions of the display shall remain blank. In this emulation mode, extended character sizing shall be utilized for legibility. The extended capabilities of the display system shall be available through the RS232 port. The emulation mode shall allow any software that operates on a standard 170E to operate with the expanded front panel system to be provided.

Via the RS232 interface, the front panel software shall provide the ability to control the LCD display system. A protocol shall be developed which shall allow full screen control of the LCD display system. This protocol shall be based on the DEC VT-100 terminal protocol. The protocol shall allow bit-mapped pixel graphics and double width and height character generation. The protocol shall be subject to the approval of the engineer. In addition, mode specification shall be provided which shall allow the system to be taken in and out of LED emulation mode. The system shall have the capability of operating the emulation mode on one part of the display while using the second part for menu driven operation.

The front panel processor shall be supplied with all required firmware to provide the stated capabilities. In addition, MSDOS readable source code and documentation shall be supplied for the front panel software.

2-7 Model 412C Program Module

A 412C PROM Module, as defined by the CALTRANS specifications, shall be provided with every controller supplied. The PROM card to be supplied shall be listed on the CALTRANS QPL list. The vendor shall supply documentation confirming the current listing on the QPL.

The PROM Card shall be configured in the following fashion:

- 27256 EPROM (32 kilobytes) Mapped to Addresses 8000-FFFF
- 8 kilobytes of Zero Powered RAM Mapped to addresses 1000-3FFF

2-8 All circuit boards of the 170E controller shall be mounted vertically.

2-9 The 170E shall be supplied with four ACIA (RS232) ports. ACIA #1 and ACIA #2 shall be terminated on standard C2 connectors. ACIA #3 shall be utilized to connect to the front panel display. ACIA #4 shall be terminated on the front panel of the controller on a DB-9 connector. This port is intended for direct connection to a portable PC computer.

2-10 All modules shall utilize digital timing in the control logic and shall utilize line frequency as a base.

2-11 All EPROM's, EEPROM's and nonvolatile RAM's shall be installed in I.C. sockets.

2-12 The maximum DC voltage generated within the controller unit shall not exceed 50 volts.

2-13 If extender boards are necessary for testing or repair, two extender boards for each type of printed circuit board shall be provided with the first unit supplied under each contract or proposal to which this specification applies. One additional extender board for each type of printed circuit board shall be provided with every five units supplied thereafter under each contract.

2-14 A programmed diagnostic package on EPROM shall be provided with each controller. This diagnostic package must be supplied for demonstration and testing prior to approval of manufacturer's unit. The program must be capable of checking all software control programs, EPROM's, EEPROM's, Processor, RAM's and localizing defective circuit components. A "wrap-around" C1 terminator shall be provided which will allow the diagnostic to verify the operation of the input and output circuitry. A "wrap-around" terminator shall be supplied with every five, or fraction thereof, controllers supplied under this contract.

2-15 Total solid state circuitry shall be employed in the controller unit. All components shall be identified by the industry standard, except manufacturer's LSI Devices.

2-16 Each controller shall be supplied with a C2 to DB-25 male connector suitable for interface to a Hayes compatible modem. The cable shall be wired to wrap-around DTR-DSR and to return the status of the Carrier Detect signal to the 170E port. The pin-out for this cable shall be subject to the approval of the Engineer.

LOAD SWITCHES - III

3-1 All load switches shall be the three circuit type and shall be compatible with the CALTRANS Model 200 switch pack and shall be equipped with three input indicator lights.

3-2 All load switches shall utilize optically isolated encapsulated modular solid state relays. Discrete components on circuit boards are not acceptable.

3-3 Each optically isolated encapsulated relay utilized in the load switch pack shall have a minimum rating of 25 amps at 120 volts AC.

3-4 A minimum of eight three-circuit load switches shall be furnished. If additional load switches are necessary to provide the timing and sequence of operation required by the intersection to which this contract applies, they must be provided as part of the assembly furnished.

CONFLICT MONITOR - IV

4-1 The conflict monitor shall be downwards compatible with the standard CALTRANS Model 210. The following extended features shall be provided:

A. The monitor shall be microprocessor based.

B An RS-232 serial port shall be provided for programming and monitoring the unit.

C. Additional monitoring circuits, not terminated on the output file connector, shall be accessed through a front panel connector.

D. Green-green, green-yellow, and yellow-yellow conflicts shall be monitored.

E. Each load switch shall be monitored for multiple outputs.

F. The watchdog function shall monitor the +24 volts DC FAILED and the cabinet +24 volts DC power.

G. The monitor shall check for display sequence errors (i.e. Green-Yellow-Green).

4-2 Once the monitor triggers, it shall assume one of two states:

A. Non-Correcting State

The monitor cannot return to normal operation without manual or input reset. Non-Correcting failures shall be stored in memory and shall be retained through an indefinite power interruption until power is once again restored and the unit is reset, maintaining the output relay de-energized until such time as the reset occurs.

B. Self Correcting State

The monitor may return to normal operation, if the condition causing the failure is corrected.

4-3 Indicator lights or liquid crystal displays shall be provided to display all active channels.

4-4 The RS232 port of the monitor shall normally be connected to ACIA #2 of the controller. However, connection to an external lap top computer shall be possible by manually switching cables. Via this port, the host computer shall be able to obtain access to the event and configuration database of the monitor.

4-5 A diagnostic package shall be supplied with the monitor unit. One diagnostic package shall be provided with the first unit supplied under each contract or proposal to which this specification applies. One additional package shall be provided with every five units supplied thereafter under each contract. The program must be capable of checking all monitor operations. All internal wiring, connections and integrated circuit socket for the diagnostic chip must be furnished and installed in the unit for immediate use.

4-6 The monitor shall be able to detect presence of conflicting green, yellow, or walk signal voltages on the AC field terminals (full or 1/2 wave) between any two or more non-compatible channels. Conflict shall always be considered a non-correcting failure.

4-7 The conflict monitor shall be capable of monitoring for the absence of proper voltage on all inputs (including red) of a channel. Therefore, a Red Failure condition shall be detected and the monitor will trigger, if at least one input per channel is not at the proper voltage level. Red failure shall always be considered a non-correcting failure. The walk shall be removable from the red failure determination via programming or dip switch.

4-8 The monitor shall initiate flashing operation as a result of absence of power to the monitor, or a failure of the monitor power supply. The monitor shall also provide an internal "watch dog" circuit for purposes of monitoring the central processor unit. If the processor fails to periodically cycle, the monitor shall initiate flashing operation.

4-9 The monitor shall provide a means of displaying the real time status of operating parameters such as time and date, functional inputs, and the on/off status of any hardware control switches. This capability may be supplied via the RS232 port of the monitor.

4-10 The monitor shall provide a setable internal 99-year clock. The clock shall automatically adjust for daylight savings time. This requirement shall be accomplished by a programmable function. As an alternate to this requirement, the manufacturer may accomplish this function in EPROM. However, if legislation changes the effective dates for daylight savings time, the manufacturer must supply a revised EPROM implementing the change.

4-11 The monitor shall store in nonvolatile memory the following information concerning each event. This data shall be retained through indefinite power interruption. A minimum of 5 events shall be logged by time and date of occurrence. As a minimum, the log shall contain the following events:

A. Power on/off occurrences

B. Failures and type (Conflict, Red Fail, etc.)

C. Display indications active at time of failure

D. Monitor resets and type (manual vs. input)

E. Exit failure occurrences (i.e., self correction)

F. Control switch changes

G. Last time/date set

H. Message overflow

I. Last printout

4-12 The monitor shall provide a means of initiating a printout sequence. The printing shall not disrupt the normal operation of the monitor. The printout shall be on A4 paper (210 by 297 millimeters), 80 column format. Alternately, the information shall be available

through a portable MSDOS computer which shall be equipped with a program, supplied by the manufacturer, which will provide this information in printout form. The report shall contain as a minimum the following:

A. Intersection Identification (7 digit number, Route number and intersection cross street)

B. Current time and date

C. Date and time of last printout

D. Current status of dip switches

E. Current status of input modifiers

F. Current programming

G. Event log as stipulated in Subsection 4-11

CABINET-AUXILIARY EQUIPMENT - V

5-1 CALTRANS 332 Cabinet Certification

The cabinet shall comply with all specifications for the CALTRANS 332 Cabinet, except as amended herein.

5-2 All harnesses shall have a nylon braided expandable self-fitting cable sleeving.

5-3 Cables shall be used for interfacing between all panels including police panel. Each cable shall have a PVC Jacket rated for 300 volts. The conductors for DC wiring shall be minimum 22 AWG Stranded Annealed Copper Wire with PVC Insulation Rated for 300 volts. The internal conductors for AC wiring shall be at least 18 AWG or as may be required for the intended usage.

5-4 The cabinet shall be a NEMA 3R enclosure constructed of a minimum of 3 millimeter thick 5052-H32 aluminum alloy. The dimensions shall be 610 millimeters W by 1 676 millimeters H by 762 millimeters D. A double door arrangement shall be utilized.

5-5 All surfaces of the cabinet shall be clean, free of holes or blemishes, smooth without burrs and with exterior corners rounded. The cabinet shall not be painted.

5-6 A thermostatically controlled fan with a minimum 2.83 cubic meters per minute airflow for ventilation, screened against the entrance to remove dust and foreign matter, shall be furnished and mounted in the top of the cabinet and completely wired and interconnected. The fan shall be wired to provide an input to the controller that the cabinet ventilation has failed. A failure of the ventilation is to be reported when the temperature in the cabinet exceeds 49 °C. The value of this temperature shall be adjustable from 21 °C to 54 °C.

5-7 A replaceable 305 by 406 by 25 millimeter filter for incoming air shall be provided.

5-8 Sufficient output file positions shall exist for 8 Vehicle Phases, 4 Pedestrian movements, and 4 overlaps.

5-9 In addition to the signal load relays and monitor unit, a solid state two circuit flasher with at least six flash transfer relays shall be furnished and mounted in the cabinet assembly. The flasher shall be equipped with Neon or LED indicators representative of the flasher outputs. Transfer relays shall be rated at 20 amps per circuit.

5-10 Unless otherwise specified in the contract to which the specification applies, phase, overlap and flash programming shall not be completed.

5-11 The following components shall be provided and mounted on the output files or PDA (Power Distribution Adapter), protected by a polycarbonate cover.

A. A mercury plunger type signal bus relay shall be installed through which the AC plus to the signal bus shall be provided when the relay is energized.

B. A plug-in "power off" relay with a clear polycarbonate dust cover. This relay shall be of such design and so connected that if the power is interrupted, the relay shall de-energize and remain de-energized until reset, denoting an interruption. However, the relay will allow the control mechanism to return to operation when current is restored. This relay shall not be resettable by the equipment, and is to be of the two-pole double-throw type, one pole for resetting and one pole for the installation of a telltale miniature lamp which shall be furnished with the equipment.

C. The cabinet control wiring and control equipment shall be protected with circuit breaker(s) of proper rating located within the controller cabinet. Separate circuit breaker (s) shall be provided for the flash operation.

D. A 120 volt AC single phase surge protector shall be installed as a precautionary measure against possible damage resulting from voltage surges on all incoming power lines. The 120 volt AC single phase surge protector shall incorporate a series choke at a maximum clamp voltage of 340 volts at 20 kiloamps with a 5 nanosecond response. In addition, the surge protector shall have the capability of removing high energy surges and block high speed transients. The surge protector shall comply with the following specifications:

Peak Current: 20 000 amps (8X20 microsecond waveshape)
Occurrences: 20 times at peak current
Minimum Series Inductance: 200 microhenries
Continuous Series Current: 10 amps
Temperature Range: -40 °C to +85 °C

If required by the contract to which the specification applies, a surrestor shall be installed for all communication lines. The surrestor shall comply with the following specification:

Peak Surge Current: 10 kiloamps amps (8X20 microsecond waveshape)
Occurrences at 2 000 amps: 50 typical
Response Time: <5 nanoseconds
Voltage Clamp: 8, 12, 20, 30, or special
Series Resistance: 24 ohms total
Operating Temperature: -40 °C to +85 °C
Primary Protector: Three element gas tube, 10 kiloamps, 8X20 microseconds, per side
Secondary Protector: Solid state clamps, 1.5 kilowatts minimum

All components, circuits and accessories considered necessary by the manufacturer to adequately protect the controller assembly and associated equipment from damage due to voltage surge shall be furnished. All devices shall be readily accessible for ease of replacement and not mounted behind any panel or enclosure.

E. A radio interference filter, shall be connected as to completely filter controller and auxiliary equipment, and shall have a minimum rating of 50 amps. This capability may be supplied as an integral part of the surge suppresser specified in Paragraph 5-11-D.

F. Three copper ground bars with brass terminal bolts capable of handling #10 wire and having a minimum of 12 terminal connecting points shall be provided and labeled AC-, chassis and logic ground.

AC-, chassis and logic ground shall be isolated from each other throughout the assembly, including any auxiliary subpanels. AC- and logic ground bars shall be mounted on insulators.

G. An additional fourth copper ground bar mounted on insulators shall also be provided on the lower portion of the power panel, having a minimum of 24 terminals, electrically connected to AC- for field wiring.

H. Spacing between ground bars on the power panel shall not be less than 38 millimeters apart.

I. All connections between the power panel and any other panel shall only be through terminal blocks on each panel.

J. All AC power assemblies shall terminate directly to the power panel not to adjacent components.

K. An UL approved convenience outlet, with ground fault protection, shall be installed.

L. Terminal block for incoming power shall be dual terminal block rated at 50 amps and shall have a minimum barrier height of 19 millimeters and utilize M5 x 8 screws.

5-12 Two input files shall be provided in each cabinet. A minimum of four pedestrian isolation circuits shall be provided in each cabinet. The input files shall be populated with sufficient dual channel detector amplifiers to operate a standard 8 Phase intersection. Additional detector and pedestrian isolators shall be provided to support the phasing configuration designated, if the standard number is not sufficient.

5-13 The following items shall be installed on a panel behind the small door located on the side of the cabinet.

A. Switch for automatic/manual operation.

B. Switch for automatic/flashing operation.

C. Switch for signals "on" and "off".

D. A manual cord consisting of 1.8 meters of rubber insulated cord and a weatherproof normally open momentary contact.

Inputs for manual control and advance shall be wired to the C1 cable on unused inputs. External flash conditions shall result in the application of a true signal to the flash sense input of the C-1 harness.

5-14 The outgoing traffic controller signal circuits shall be of the same polarity as the line side of the power supply; the common return of the signal circuits shall be of the same polarity as the ground side of the power.

5-15 Field terminals utilized in the cabinet assembly shall be of the double row high type barrier blocks. They shall be rated at 50 amps and shall have a minimum barrier height of 16 millimeters and shall utilize M4 x 8 screws as a minimum. All connections to the field terminal blocks from load switch bases and flash transfer relay bases in the output files shall be made with vinyl insulated spade connectors.

5-16 Sufficient terminal blocks rated at 50 amps shall be supplied to terminate spare field conductors (maximum 3 conductors per terminal), as required by the contract which this specification applies.

5-17 All cabinet doors shall incorporate hinges and hinge pins utilizing stainless steel. Fastening of hinges to doors and cabinets shall be made using stainless steel pop-rivets or stainless steel nuts and bolts. Welding of hinges to cabinets and doors shall not be permitted. Steel may only be utilized for 483 millimeter chassis rack mount rails and shall be treated to prevent corrosive effects.

5-18 Each cabinet door shall be equipped with a switch which will provide input to the controller that the cabinet door is opened. Conflict monitor operation shall not be disabled while the cabinet door is open.

5-19 The use of printed circuit boards on the AC signal load drive circuitry will not be permitted.

5-20 A fluorescent fixture supplied with a lens or shield and a 15 watt Type T-12 lamp and rapid start, high power factor cold weather ballast shall be supplied and installed in the top front and rear of the cabinet. A switch shall be installed on the inside of the cabinet doors or near the police panel, to manually disable the lamps.

5-21 Both cabinet doors shall be supplied with CCL 2-NJIVHS or equivalent locks.

5-22 The cabinet shall be supplied with a slide out shelf/drawer storage unit.

CONTROLLER TESTER - VI

6-1 The controller tester shall be housed in a high impact ABS Plastic suitcase enclosure not to exceed the dimensions of 508 by 381 by 178 millimeters and weighing less than 6.8 kilograms.

6-2 The tester shall include a C-1 connector with harnesses of at least 1.8 meters in length.

6-3 The tester shall include phase displays and intersection display modules. The intersection display shall have LEDs to simulate all eight phase outputs, four pedestrians, and at least four overlap phases.

6-4 The tester shall be wired to be compatible with Model 332 cabinets.

6-5 All C-1 inputs shall be connected to three position toggle switches. These switches shall simulate special functions and detector inputs and shall be labeled with their C-1 designations.

6-6 All C-1 outputs shall be represented by LEDs, including the watchdog output.

6-7 The tester shall include a power interrupter which can be programmed to simulate power failures to the controller of 0.1 to 2.5 seconds.

6-8 One controller tester shall be supplied with every fifteen controller/cabinets or fraction thereof delivered under this contract.

CABINET TESTER - VII

7-1 The cabinet tester shall include a mechanism to simulate AC inputs to the conflict monitor to verify conflicting signal indications.

7-2 The tester shall include a sub-system which simulates a 170E controller. This subsection shall have a C-1 connector, identical to the 170E's connector, into which the cabinet's C-1 harness can be connected. The panel shall have switches for each C-1 output to simulate phase displays. In addition, a watchdog output shall be provided which can be switched in and out by toggle switch. The panel shall also have LED displays to simulate all inputs to the controller from the cabinet.

7-3 The tester shall have a display unit which contains 25 watt incandescent lamps for each of the load switch outputs of an output file and shall be equipped with a harness suitable for connection to the output file.

7-4 The tester shall include a set of 26 test cards, two tone test cards, input file test gun, and output display unit. The standard test cards shall be equipped with LEDs to indicate the status of each output and two switches to enable the operator to ground each output line to the C1 connector. The tone cards shall contain an annunciator which shall emit a short tone, a sequence of several tones, or no tone depending upon the correct signal sequence monitored.

7-5 One cabinet tester shall be provided with every twenty-five or fraction thereof controller/cabinets delivered under this contract.

TRAINING - VIII

Prior to the acceptance of the first unit of each type, training shall be provided for the Department's engineering, maintenance and operations staff, at a facility provided by the Department. The training shall include all material and manuals required for each participant. The training shall be as follows:

8-1 Maintenance Training

The training shall be provided for a minimum of 40 hours for at least five (5) personnel with an electronics background. The training shall include operation instructions, theory of operation, circuit description, field adjustments, preventive maintenance procedures, troubleshooting, operation of diagnostic software, operation of the controller and cabinet test sets, and repair of all components.

8-2 Engineering Training

The training shall be provided for a minimum of 24 hours for at least twenty (20) engineering and operations personnel. The training shall include a complete demonstration of the operation and capabilities of the equipment. This session should include a complete review of the programming of the conflict monitor, controller operation, cabinet wiring, diagnostic software, and any field adjustments or calibration of the equipment which may be necessary for optimum performance and should stress day-to-day operation and isolation of problems down to the unit level. For example, procedures should be discussed of identifying a faulty module in the field, as opposed to board level repairs covered in Subsection 8-1. Particular attention shall be given to the operation of the PC based diagnostic program.

INSTRUCTIONS AND GUARANTEES - IX

9-1 One set of complete schematics and maintenance manuals of the controller unit, monitor and auxiliary equipment shall be supplied with each controller assembly furnished.

9-2 One reproducible blackline Diazo mylar (0.1 millimeters thick) A1 size (594 by 841 millimeters) and two prints of the schematic wiring diagram for the cabinet wiring,

including all input and output files, shall be supplied with each controller assembly furnished. The schematic wiring diagram shall contain the following information in at least 6 millimeter lettering.

A. Contract and bid dated.

B. Model and number of all equipment.

C. Intersection location.*

* When not applicable, the diagram shall have the word "location" and a blank space where the intersection can be added.

9-3 No changes or substitutions in these requirements will be acceptable unless authorized in writing. Inquiries regarding this specification shall be addressed to the Manager, Office of ITS Engineering, New Jersey Department of Transportation, P.O. Box 613, 1035 Parkway Avenue, Trenton, New Jersey 08625.

9-4 The complete control and auxiliary equipment shall carry a two-year guarantee from the date of acceptance against any imperfections in workmanship or materials. Any tests or repairs made by a manufacturer or representative shall be documented on the New Jersey Department of Transportation "Equipment Failure Analysis and Report Form" and returned with units when warranty repaired. The Department will attach a copy of this form to all returned equipment. This documentation shall include an explanation of the exact repairs made and identification of parts replaced by part number and circuit number. All warranty repairs must be made within thirty days upon receiving equipment.

9-5 The Supplier agrees upon the request of the Manager, Office of ITS Engineering to deliver to the Office, a sample of the control equipment to be supplied in compliance with these specifications for inspection and test before acceptance. After completion of the test, the sample shall be returned.

9-6 The Supplier shall furnish any and all equipment which they deem necessary for safe and reliable field operation of the control equipment.

9-7 All equipment furnished under this specification must be derived from components currently on the CALTRANS QPL list and shall be current production equipment and of recent manufacturer, similar models of which are field operational. Untried or prototype units shall not be considered for acceptance.