ITEM 10680.0010 M - LIGHT EMITTING DIODE BLANKOUT SIGN

DESCRIPTION:

This work shall consist of furnishing and installing light emitting diode (LED) blankout signs (BOS) at locations indicated in the contract documents or as directed by the Engineer. The contractor shall furnish and install all necessary equipment in strict conformance with the manufacturer’s specifications and as directed by the Engineer.

MATERIALS:

BOS size, message content, lettering size and style, structural details, and materials shall be as specified herein, and as shown on the plans. The BOS shall be capable of displaying up to three distinct messages including blank message. The furnished LED BOS shall include all electrical and electronic hardware, structural materials, housings, and computer hardware and software required for a fully operational, integrated, real-time system. The LED BOS, and its associated equipment, shall be capable of operating on a 24 hour a day, 7 day per week basis and shall conform to the physical and functional requirements of this section and the plans.

The LED BOS shall be composed of all items of hardware and software necessary to generate, transmit, and effect the display of message text utilizing light emitting diode technology. The LED BOS shall consist of light emitting diode sign panels and driver electronics with a suitable enclosure and a microprocessor based controller unit. The entire BOS assembly shall be housed in a complete and fully wired aluminum weatherproof enclosure. The LED BOS shall provide clear readable messages in all normally encountered highway weather and lighting conditions.

In general, the LED BOS shall consist of readily available and proven hardware and software elements, fully consistent with the intended design and operation. Special or custom built components may be used only upon written approval from the Engineer. Use modular type construction with assemblies, sub-assemblies and modules that are available from a second source of supply, wherever possible.

The BOS shall operate from a local microprocessor based controller with sufficient on-board memory and I/O interfaces to provide all the functions required herein. At a minimum, the sign shall accept up to three separate discrete inputs from other local control devices and display the associated messages as shown on the plans.

The presence of ambient radio signals, magnetic or electromagnetic interference, including those from power lines, roadway lights, transformers or motors, within 0.3 m of any of the components of the LED BOS, shall not impair the performance of the BOS System. The LED BOS shall not radiate any electrical or electromagnetic signals that could adversely affect any other electrical or electronic device.

General Material Requirements

The LED BOS shall be composed of LED pixel based matrix display modules. The LED BOS shall be single faced, with the message face arranged as to display the messages as indicated on the plans. All message lettering and symbols shall comply with the size, dimensions and graphic characteristics specified on the plans.

All matrix modules shall be interchangeable and replaceable. Each pixel shall function on a two position basis (on or off) and shall be individually addressable and controllable to allow for the display, on any portion of the message face, of static text or the flashing of all or any part of the text, together with message formation by alternating between two or more static or flashing text messages.
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The default position for all text displays shall be automatically centered horizontally and vertically, and be proportionally spaced, unless otherwise indicated on the plans or explicitly indicated in the text message through line and page justification.

LED Specifications

The LEDs used in the BOS shall conform to the following:

- The LED's that make up the display modules shall be high luminous intensity T-1 19 mm type Aluminum Indium Gallium Phosphide AlInGaP II lamps as approved by the Engineer. The LED's shall have an ultraviolet light inhibitor in the epoxy dome package and be of a production type already tested for use in high vibration commercial traffic environments and climate of the northeastern United States.

- The light emitted by the LED display shall be amber, with a dominant wavelength centered at 592 nanometers, plus or minus 2 nanometers. The use of cluster lamps made up of red and green LED's, with both colors turned on simultaneously to obtain a perceived amber light, as a substitute for the AlInGaP II lamps, shall not be acceptable.

- The LED shall provide a minimum radiation pattern of 70 degrees along the major axis (horizontal with respect to the BOS face) and a minimum of 35 degrees along the minor axis. The discrete LED’s oval shaped radiation pattern shall produce a cone with a minimum viewing angle (one-half on-axis intensity value) of 35 degrees, centered about the optical axis of the lamp, and horizontal to the BOS face.

- The LED mean time before failure (MTBF) shall be a minimum of 100,000 hours of elapsed time calendar hours use in an ambient temperature of 60°C, based on an average daily on-time usage factor of 11%, when driven at the specific forward current used for normal daylight LED BOS display operation. As part of the LED manufacturer's technical specification sheet submittal, the specific forward current shall be noted.

- The LED's used in the display shall be obtained from batches sorted for luminous output, where the highest luminosity LED in the batch shall not be more than fifty percent more luminous than the lowest luminosity LED in the batch. To ensure uniformity of display and operational life, all LED's used to make up a display module shall be obtained from the same manufacturing batch.

LED Display Modules

- The LED display modules shall have a minimum refresh rate of 60 frames per second.

- The LED's shall be grouped in pixels consisting of discrete LED's arranged in a discrete matrix display with individual pixel addressability. The centers of all pixels shall be spaced so as to maintain the same horizontal and vertical clearances between adjacent pixels. All pixels shall be replaceable. The LED grouping and mounting angle shall be optimized for maximum readability.

- The electronics for the LED BOS shall be fully configured to drive the total required number of LED's. The failure of any one pixel shall not affect the operation of any other pixel. The power driver circuitry shall be designed to minimize power consumption. Each LED display module shall have a diagnostic capability to detect a failure on the LED display module, down to the pixel level and report the failure to the BOS controller.
The LED driver electronics shall not be mounted on the same board as the LED displays. The driver boards shall be easily disconnected from the LED display modules. Removal of any display module shall not affect the operation of the remaining modules.

The LED BOS shall be protected from degradation due to sunlight. The method used shall not obstruct the view of the display or reduce the viewing angle below that provided by an unprotected LED BOS. The method and design of the LED BOS sunlight protection shall be approved by the Engineer.

A sufficient number of discrete LED shall be used in each pixel to produce a minimum luminous output of 17.0 candelas per individual pixel, based on a pixel spacing of 43.5 mm, in order to satisfy minimum luminous output requirement of 9000 candelas per meter square, when each discrete LED in the pixel is driven at a current of 20 milliamperes measured on the mechanical axis of the lamp package.

The contractor shall submit the design calculations and product documentation to demonstrate that the luminous output of the display modules will meet these requirements.

Sign Face Details

The BOS face shall have a weather tight polycarbonate plastic super abrasion resistant window, or approved equal.

Where possible, the BOS face window shall be one continuous sheet. Multiple sections with seams shall only be acceptable where the size of the sign will not allow for the installation of one continuous sheet, and with the approval of the Engineer. The number of seams shall be kept to a minimum. Seams shall be water-tight, transparent and shall not obscure the viewing of the displayed message by oncoming traffic.

The BOS face window shall be both replaceable and shatter resistant.

The pigmentation of the polycarbonate and its optical characteristics shall be matched to the wavelength of the LED's to guarantee the transmission of at least 80% of the light emitted, as certified by the polycarbonate manufacturer.

The BOS face window shall be ultraviolet (UV) inhibiting, providing a minimum reduction of 80% of both UV type A and UV type B light that reaches the LED's, as certified by the polycarbonate manufacturer. Any substitutions must be approved by the Engineer.

The BOS face window material shall meet the following requirements:

Minimum Thickness: 6.4 mm
UL94 fire rating V1

The BOS face and enclosure shall be gasketed, weatherproof and dust tight, when assembled and closed. Gasketing shall be 6.4 mm, minimum, thickness closed cell neoprene, permanently bonded to the metal. The mating surfaces of the gasketing shall be covered with a silicon lubricant to prevent sticking. The lubricant used shall not degrade the neoprene over time.

The BOS face window shall not be adversely affected by salt from the roadways or marine environments or chemicals or fumes discharged from nearby automobiles, industries and other sources.
The external BOS face shall have a non-glare finish.

The BOS face shall be flat black. The sides and rear of the BOS enclosure shall be unfinished, non-reflective aluminum, with brush finished texture to match the existing sign structures. Material and color samples for the BOS face shall be submitted to the Engineer for approval.

All LED BOS shall be single faced, with the message face arranged as indicated on the plans.

The message display shall be arranged from a sufficient number of display modules, each comprised of a sufficient number of individual LED's to meet the legibility, luminosity and viewing angle requirements of this specification. As a minimum the message display shall be arranged from a sufficient number of display modules and pixels to produce the number of individual display characters shown on the contract drawings, as if each nominal character was formed from a matrix that is a minimum of 5 columns wide by a minimum of 7 rows high, based on a pixel spacing of 43.5 mm.

The display shall produce characters that are 304.8 mm in height produced from a vertical column containing a minimum of 7 pixels.

Each pixel shall consist of a minimum of 9 discrete LED's, based on a pixel spacing of 43.5 mm to meet the luminosity requirements herein. As a minimum each pixel shall consist of 2 separate strings of LED's. The failure of any single string of LED's shall not result in more than 50% loss of light per pixel.

The full graphic display of the LED BOS shall be clearly visible and legible from in-vehicle viewing distances of 183 m to 9.1 m from the BOS face under clear daylight and nighttime conditions with the BOS face positioned in the roadway line of sight configuration shown on the plans.

The final display character layout, arrangement of modules, the quantity and arrangement of pixels per module and the quantity and arrangement of LED's per pixel shall be approved by the Engineer.

Sign Enclosure Details

The LED BOS Enclosures shall be of such design and shape as to house all necessary LED display modules, LED display driver electronics, display control hardware, transformers and power supplies unless otherwise indicated on the Contract Drawings. The overall dimensions of the required LED BOS enclosure shall be as shown on the Contract Drawings. The Contractor shall submit Fabrication and Shop Drawings and design calculations for all BOS enclosures, ventilation and mounting, sealed by a Professional Engineer licensed in New York State.

The LED BOS enclosures shall be constructed of corrosion resistant aluminum material conforming to the following:

- Sheet aluminum shall be fabricated from aluminum alloy sheet meeting the requirements of ASTM B 209, Alloy 5052, Temper H3, or equivalent, minimum 3.2 mm thick.
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- Cast aluminum shall be fabricated from aluminum alloy meeting the requirements of ASTM B 686, Alloy A 356 (A 13560) or equivalent. Flat cast surfaces exceeding 304.8 mm in both directions shall have a minimum thickness of 6.4 mm. Flat cast surfaces not exceeding 304.8 mm in both directions shall have a minimum thickness of 4.8 mm.

- All LED BOS enclosures shall meet the requirements for TYPE 3R enclosures according to NEMA Standard Publication 250. All seams and openings shall be designed to prevent entry of water resulting from high pressure washing of the LED BOS enclosure.

- Unpainted aluminum BOS enclosures shall be fabricated from mil-finish material and shall be cleaned using appropriate methods that will remove oil, film, weld black, and mill ink marks and render the surface clean, bright, smooth and non-sticky to touch.

- Isolate all adjacent dissimilar materials, as approved by the Engineer.

- The finished BOS enclosure colors shall be as indicated on the plans. Finish color samples shall be submitted to the Engineer for approval.

- All nuts and bolts used in the BOS assembly shall be stainless steel. All connecting surfaces shall be weatherproof and watertight when secured. All internal components shall be mounted so that there are no external protrusions.

- The LED BOS shall be in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except as modified herein.

- The BOS enclosures shall be designed and constructed to present a clean, neat appearance and the equipment located inside shall be adequately protected from moisture, dust, dirt, corrosion, and excessive heat.

- All surfaces shall be suitably protected from the weather and painted. All corners and seams shall be heli-arc welded to provide a weatherproof seal around the entire case.

- The LED BOS enclosure shall not be adversely affected by salt from the roadways or marine environments or chemicals or fumes discharged from nearby automobiles, industries and other sources. The interior of the BOS face window and the LED's shall be easily accessible for cleaning and other maintenance.

- Appropriate precautions, such as heating elements or ventilation fans or openings, shall be taken to ensure that condensation does not occur between the matrix elements and the BOS window face, and that the environment inside all enclosures remains within the temperature and humidity limits required for proper operation of the signs electronic components.

- All hinges used shall be continuous stainless steel, equipped with stainless steel hinge pins. Each hinge shall be secured with stainless steel bolts and lock nuts. The hinge pins and bolts shall be tamper proof.

- The dead load shall consist of the total weight as installed of the BOS enclosure and appurtenances. The point of application of weights of the individual items shall be their representative centers of gravity.

- Ice load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals except that ice load shall be applied to all sides and top surfaces of the BOS enclosure simultaneously.

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- Wind load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals except as modified herein. The enclosure and their mountings shall withstand a sustained wind speed of 145 km/h, with a gust factor of 1.3.

- Full 100 percent impact shall be used for handling and erection stress.

- The Contractor shall furnish mounting brackets that will allow for field adjustment of the BOS housing for optimizing the viewing angle after installation.

- The signs shall be capable of being mounted without gaining access to the inside of the enclosure. Any mounting eyes shall be attached to the BOS enclosure structural framing. The LED BOS enclosure shall be adaptable for mounting as shown on the plans.

- Removal of any of the display modules or any other electronic or electrical component, shall not alter the structural integrity of the BOS display assembly or the BOS enclosure.

- Access to the interior components of the LED BOS shall be via continuous top-hinged doors with locking struts designed to hold the doors open. Automatic opening type struts shall not be used. Door struts shall be capable of holding the door open at 90 degrees in a 97 km/h wind, acting perpendicular to the door. The door struts shall not be released automatically or by the action of the wind on the open door. Wherever possible, access doors shall be designed to allow for opening by a single person. The release of door latches shall be by hand or require only simple, common hand tools. If bolts or screws are used for securing doors, they shall be captive type, to prevent them dropping onto the roadway below when removed. The door shall not interfere with the operation of the BOS display when the door is held open or is closed.

- Drain holes shall be provided and designed to remove any condensation that may form inside the BOS enclosure and allow any water that may have collected in the housing to escape. All holes shall be screened to prevent small objects, insects and creatures from entering into the enclosure.

Power Supply

- The LED display shall be operated at a low internal DC voltage not exceeding 24 Volts.

- The quantity of power supplies and current rating of each power supply shall be at least 50% spare capacity over that required to light every pixel of the LED BOS.

- The LED BOS and controller shall have redundant power supplies wired so that in the event of a failure of any one power supply, the second power supply shall be capable of powering that portion of the sign.

- The power supplies shall be short circuit protected and shall reset automatically after 5 seconds of AC power off. The power supplies shall be protected by a suitable overcurrent protection device, as approved by the Engineer.

- The power supply shall have an efficiency rating of 75%, minimum.

- The operating range of the power supply shall be -30°C to 60°C.

- The power supply shall be UL listed.
Controller Requirements

The BOS controller shall be a microprocessor based unit with sufficient on-board memory, input and output interfaces, to provide all the functions required herein. At a minimum, the controller shall accept discrete inputs from up to three separate local control devices and display messages as shown on the plans.

Each BOS controller shall have an easily accessible and clearly labeled ON/OFF switch. When in the "OFF" position all power shall be disconnected from the BOS control electronics and matrix units and the LED BOS displays shall automatically blank out.

The BOS controller shall have a momentary contact switch which resets the BOS controller when depressed.

The BOS shall be furnished with all relay and switching electronics necessary to display the messages as required.

Electrical Requirements

All equipment supplied shall operate from 115 volts ± 20 volts, 60 Hz. ± 1 Hz, unless otherwise noted on the Contract Drawings. Any and all transformation equipment required shall be supplied by the Contractor. The equipment shall have surge suppressors and have automatic recovery from a power failure and shall be "brownout" and "transient" protected.

All wiring and conduits shall be in accordance with the requirements of the NFPA-70, or any local codes having jurisdiction at the installation site, and as shown on the Contract Drawings or specified herein. No wiring shall be exposed.

Electrical field connections shall be provided by barrier type terminal connection blocks as defined in NEMA Standard Specification No. TS-1. All terminal block connections shall be identified and readily accessible for maintenance. All wire and cable terminations shall be made with insulated spade terminals as defined in NEMA Standard Specifications No. TS-1. Soldering of field terminal connections shall not be permitted.

The circuit number of all cables and wires shall be identified by permanent cable tags attached to each of the cables or wires in all junctions boxes, sign panels and cabinets. The cable tags shall be secured to the cable or wire with nylon cable ties. All wires shall be neatly laced into cables with nylon lacing, or approved equal. All cables shall be secured with nylon cable clamps and permanently attached to the cabinet or enclosure using an attachment mechanism approved by the Engineer. Adhesive-backed cable tie mounts shall not be used to secure cables or wires to the cabinet or enclosure. Spare wires shall be properly terminated and identified as such. All wires shall be neatly routed to their connections.

All conduit connections to the BOS enclosures shall be watertight and allow for adjustment of the BOS enclosures for optimum viewing. Methods and materials used shall be approved by the Engineer, prior to installation of the signs. Power and communications cables connected to the LED BOS shall be run in separate conduits. The running of power and communications cables in the same conduit shall not be acceptable.

Where a cable or wire passes through a hole or runs along a surface at any point through or on a completed assembly, such holes and/or surfaces shall be deburred and void of any sharp edges that may damage the cable or wire passing through or along the surface. All deburred holes shall be equipped with a rubber or plastic grommet.

Cable
The cable type, gauge and number of conductors shall be as shown on the plans. In order to increase flexibility when pulling, cable shall be stranded copper wire, unless otherwise shown. Individual conductors shall be color-coded as per IMSA Specifications 19-1 and 19-3.

Where joints or splices are necessary, they shall be made with a solderless compression connector and shall be secured mechanically and electrically with the proper tool. The conductors shall be thoroughly cleaned immediately prior to splicing/joining, with a minimum of insulation removed.

All joints or splices, except those in junction boxes, shall be insulated with insulation tape and thoroughly coated with an electrical grade sealant and bonding compound.

Where joints or splices are necessary in junction boxes, they shall be as specified above and insulated with resin splicing kits.

Any tape supplied in any splice or terminal kit shall have been manufactured no longer than six months prior to its use, and shall be dated by the tape manufacturer to so indicate.

**Sign Enclosure and Control Connections**

The gauge of all insulated wires between various parts and components shall be of adequate size, in accordance with NFPA-70, or any local codes having jurisdiction. All BOS enclosure and control cabinet wiring shall be in accordance with NEMA Standard Specification No. TS-1 or approved equal.

All terminal blocks and strips located within the BOS enclosures and control cabinets shall be accessible to the extent that it shall not be necessary to remove any equipment from the housing to make an inspection or connection.

All wires shall be cut to their proper length before assembly. No wire shall be doubled back to make up for unnecessary slack. However, sufficient slack shall be provided such that any wire end can be cut back, re-striped and connected at least twice.

All electrical connections in the BOS enclosures and cabinets shall have sufficient clearance between each terminal and the housing so as to prevent a leakage path or physical contact under stress. The lay of the interconnect cables between components shall be such that when the housing door is closed, it will not press against the cables or force the cables against various components inside the housing.

The ground side of service shall be carried throughout all BOS enclosures and control cabinets without a break. All equipment grounds shall run directly and independently to the ground bus. The grounding strip shall be connected directly to the housing wall. Grounding shall be in accordance with standard details.

**Circuitry Protection**

Appropriate devices shall be installed in the BOS enclosure and local control cabinets to protect the LED BOS electronics from over-voltage situations, such as lightning strikes and power surges over the lines. Circuitry protection shall include, but not be limited to:

All A.C. power utility outlet circuit(s) located within the LED BOS and all associated control equipment enclosures, shall be protected by Ground Fault Circuit Interrupting type devices.

Surge protector to guard against circuit damage resulting from voltage surges on all incoming power lines. The surge suppressor shall meet the following minimum specifications:

- Maximum clamp voltage: 340V
- Peak Current: 20,000 Amps
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Response Time: 5 nanoseconds
Occurrences: 20 times at peak current
Minimum Series Inductance: 200 microhenries
Temperature Range: -40°C to 85°C

Telephone line and RS-232 Data Line protectors to guard against circuit damage resulting from voltage surges on all communications lines.

Separate protection devices shall be installed at each sign location and shall be readily accessible for ease of replacement. The components shall be plug-in or screw-in units, which require virtually no System down time to replace. The devices shall be clearly and permanently labeled.

The sign panels shall be electrically bonded to the support structure. This bonding shall consist of an electrical bond wire or properly prepared electrical contact points.

Identification

A block diagram of all components illustrating all connectors and connections used to interconnect the components, wiring diagrams and schematic drawings of all circuits shall be inserted in a resealable weather-resistant pocket that is permanently mounted on the inside of an accessible door in the ground-mounted controller cabinet.

The component name and model number shall be inscribed using a permanent label or laminoid name plate in a position adjacent to the location of each major or replaceable component on the inside of the cabinet and enclosure.

All devices, components, cables and wires shall be indelibly identified on permanently attached labels designed for use in the intended environment using labels approved by the Engineer, and inscribed in accordance with the approved schematic diagrams and layout drawings.

All internal connectors and wire terminations shall be labeled with sufficient information to locate its connection point without recourse to any other documentation located outside the controller cabinet or enclosure.

Component Identification

Each printed circuit and higher level assembly shall be clearly marked with the manufacturer's part number and the revision level of the assembly. Changes to components shall be indicated by an unambiguous change to the marked revision level.

All electronic parts (such as capacitors, resistors and integrated circuits) shall be marked, either with the characteristics of the part or with an industry standard part number. Custom parts, such as Read Only Memories, shall be labeled to identify the information, the revision level, date and checksum of the information stored.

All printed circuit card cages, all slots within the cages and all printed circuit card interconnection cables shall be clearly labeled. Printed circuit cards and cable connectors shall be keyed to prevent insertion into incorrect locations.

All printed circuit boards shall be FR4 or G10 fiberglass epoxy material (phenolic is not acceptable), double sided with plated through holes. All connectors and connector fingers shall be gold plated. Each board shall have a moisture proof conformal coating.

Mechanical Requirements
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All bolted connections other than high strength friction bolted connections shall be provided with lockwashers, locking nuts, or other suitable means to prevent the connection nuts from backing off. All shop connections shall be either bolted or welded. Field welding shall not be permitted. All connections to supporting structures shall be bolted.

Dissimilar materials shall be isolated by stainless steel plates or other stainless steel fittings. Stainless steel bolts shall be used for connection at the locations. Coating or plating shall not be considered adequate for isolation of dissimilar metals or other connections.

Welding of aluminum shall consist of inert gas shielded metal arc welding with consumable electrodes. All welding of aluminum shall be performed in the shop. No field welding of aluminum shall be permitted.

**Environmental Requirements**

All LED BOS equipment shall be designed for outdoor use and operate over an ambient temperature range from -40°C to +50°C and humidity of 0% to 100%, non condensing. Operation of the LED BOS equipment shall not be degraded by sun, heat, rain, snow, fog, ambient humidity, or other weather conditions normally encountered in the installation area.

All equipment shall operate without degradation or damage under all weather conditions, vibration, lightning, and electromagnetic/electrical interference existing at the location where the LED BOS is installed.

The complete LED BOS assemblies shall conform to the requirements of current NEMA Standard No. TS-1, section 2, "Environmental Standards and Test Procedures", except as amended and supplemented herein. The manufacturer shall supply certification for equipment and compliance with NEMA environmental standards in accordance with NEMA testing procedures.

**CONSTRUCTION DETAILS:**

The sign shall be built and installed on either overhead sign structure or ground mounted sign posts in accordance with the details shown on the plans.

All material shall be transported and handled in a manner that will cause no permanent deformation, injury or damage. Material to be stored shall be stored above the ground in a manner and at a location approved by the Engineer. Any part of the entire sign or structure damaged during transportation, handling or erection shall be repaired, or if determined by the Engineer as unfit for use in the finished work, shall be removed from the site and replaced by the Contractor at his own expense.


**Design and Layout Review**

The Contractor shall furnish cut sheets, shop drawings and block and schematic diagrams which show in detail all proposed materials, dimensions, electronic layouts, part numbers, part values and operation parameters prior to construction of the BOS for the approval of the Engineer.

**Documentation Requirements**

Ten (10) complete sets of operation and maintenance manuals shall be provided. The manuals shall, as a minimum, include the following:

- Complete and accurate schematic diagrams.
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- Complete installation procedures.
- Complete performance specifications (Functional, electrical, mechanical and environmental) on the equipment.
- Complete parts list including names of vendors for parts not identified by universal part numbers such as JEDEC, RETMA, or EIA.
- Pictorial of component layout on circuit board.
- Complete maintenance and trouble-shooting procedures.
- Complete stage-by-stage explanation of circuit theory and operation.

Experience

The LED BOS manufacturer shall have been in the business of manufacturing LED BOS and BOS Systems equivalent to that specified in this Section for a minimum of 5 years.

The LED BOS manufacturer shall have maintenance services and related technical assistance available in the New York City Metropolitan Area.

BOS System equipment of the type furnished under this Contract, shall have been satisfactorily installed and operational in at least three different sites with similar environmental conditions to those of the installation site and in applications of similar or equivalent complexity to that specified in this Contract, for a period of not less than two years. Of these three, at least two shall have LED BOS used on a highway in a vehicular traffic control application. Trailer mounted LED BOS shall not be acceptable for meeting the highway vehicular traffic control application experience.

The LED BOS and all associated BOS System equipment, shall all be furnished by the same manufacturer.

Testing

Three (3) types of tests shall be required for each unit of equipment furnished: Design Approval Tests, Stand-Alone Tests, and System Acceptance Tests. Each of these tests are described in the following sections.

The Contractor shall be responsible for developing detailed test procedures for each type of equipment and for conducting the specified tests to verify satisfactory operation of the equipment. The test procedures shall be submitted to the Engineer for approval prior to the tests. Only approved test procedures shall be used during the tests. A minimum of ten (10) work days shall be allowed for the Engineer's review and approval of the test procedures.

The Engineer shall be notified in writing a minimum of ten (10) work days in advance of the time when these tests are to be conducted.

The results of each test shall be compared with the requirements specified herein. Failure to conform to the requirements of any test shall be counted as a defect, and equipment shall be subject to rejection by the Engineer.

Rejected equipment may be offered again for retest provided all non-compliances have been corrected and retested by the Contractor and evidence thereof submitted to the Engineer.
Final inspection and acceptance of equipment shall be made after installation at the locations specified on the plans unless otherwise specified herein.

Design Approval Test

Design approval tests shall be conducted by the Contractor on one or more sample equipment of each type, as approved by the Engineer, to determine if the design of the equipment meets the requirements of this specification. The tests shall be conducted in accordance with the test procedures prepared by the Contractor and approved by the Engineer as described in the above section.

In the case of standard product line equipment, the Engineer may waive the design approval tests if the manufacturer's written specifications (functional and environmental) are equal to or better than those specified herein and he so states in writing or if the Contractor provides certification by an independent testing laboratory that these design approval tests have been previously satisfactorily completed.

The LED BOS components shall conform to the requirements of current NEMA Standard No. TS-1, section 2, "Environmental Standards and Test Procedures", except as amended and supplemented herein. All environmental testing shall be successfully performed prior to installation of the LED BOS equipment in the field. The manufacturer shall supply certification for equipment and compliance with NEMA environmental standards in accordance with NEMA testing procedures.

Environmental

The LED BOS enclosure shall be certified to meet the most recent revision design test requirements for a NEMA type 3R enclosure, including external icing, hosedown and corrosion protection.

Vibration

All LED BOS components shall provide continuous normal operation and physical integrity when subjected to a vibration of 5 to 30 cycles per second up to 0.5 gravity applied in each of the three mutually perpendicular planes.

Shock

All LED BOS components shall not suffer any permanent mechanical deformation or damage that renders the unit inoperable, when subject to a shock of 10G applied in each of three mutually perpendicular planes.

Power Service Transients

The LED BOS shall provide continuous uninterrupting operation when the independent test pulse levels specified herein occur on the AC power service:

High-Repetition Noise Transients

The test pulses shall not exceed the following conditions:

Amplitude: 300 Volts, both positive and negative polarity.

Peak Power: 2500 Watts
Repetition: 1 pulse approximately every other cycle moving over the full wave in order to sweep across 360 degrees of the line cycle once every 3 seconds.

Pulse Rise Time: 1 microsecond
Pulse Width: 10 microseconds

**Low-Repetition High-Energy Transients**

The test pulses shall not exceed the following conditions:

- Amplitude: 600 volts ± 5 percent, both positive and negative polarity.
- Energy Source: Oil filled, 10 microfarad ± 10 percent, capacitor with internal surge impedance less than 1 Ohm.
- Repetition Pulse: 1 discharge every 10 seconds.
- Position: Random across 360 degrees of the line cycle.

**Input-Output Terminal Transients:** The LED BOS shall provide continuous uninterrupted operation when the test pulse occurs on the input-output terminals:

- Amplitude: 300 Volts, both positive and negative polarity
- Pulse Source: 1000 Ohms nominal impedance
- Repetition: 1 pulse per second, for a minimum of 5 pulses per selected terminal.
- Pulse Rise Time: 1 microsecond
- Pulse Width: 10 microseconds

**Non-destruct Transient Immunity:** The LED BOS shall be capable of withstanding a high energy transient having the following characteristics, repeatedly applied to the AC power input terminals (with no other power connected to the terminals) without failure of the test specimen:

- Amplitude: 1000 Volts ± 5 percent, both positive and negative polarity.
- Energy Source: Oil filled, 15 microfarad ± 10 percent, capacitor, with internal surge impedance less than 1 Ohm.
- Repetition: Applied to the LED BOS once every 2 seconds for a maximum of 3 applications for each polarity.

After the repetitive application of the high energy transient, the LED BOS shall perform all functions defined herein, upon application of normal AC power, without failure or replacement of any component of the LED BOS.
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All electrical materials and equipment used for which there are established Underwriters Laboratories (UL) and Electrical Testing Laboratories (ETL) standards shall bear the UL and ETL labels.

If the equipment fails the design approval tests, the design fault shall be corrected and the entire design approval test shall be repeated. All deliverable equipment shall be modified, without additional cost to the State, to include design changes required to pass the design approval tests.

Stand-Alone Test

The Contractor shall conduct an approved stand-alone test of the equipment after installation at each field site shown on the plans. The test shall, as a minimum, exercise all stand-alone (non-network) functional operations of the equipment with all of the equipment installed per the plans as directed by the Engineer. Approved data forms shall be completed and turned over to the Engineer as the basis for review and rejection or acceptance.

If the equipment fails the stand-alone test, it shall be corrected or another substituted in its place and the test successfully repeated. If a unit has been modified as a result of a stand-alone test failure, a report shall be prepared and delivered to the Engineer prior to retesting of the equipment. The report shall describe the nature of the failure and the corrective action taken. If a failure pattern, as defined by the Engineer, develops, then he may direct that design and construction modifications be made to all equipment without additional cost to the State or extension of the contract period.

Final Acceptance Test

Following satisfactory completion of the stand-alone test, the Contractor will integrate the BOS equipment into the local control system and a final acceptance test shall be conducted.

The final acceptance test shall, as a minimum, exercise all functional operations of the equipment as an integrated system. The test shall demonstrate all remotely controlled features and all local controlled features specified herein.

METHOD OF MEASUREMENT:

The LED Blankout Sign will be measured as the number of complete signs furnished, installed and tested in accordance with the Contract Documents or as ordered by the Engineer.

BASIS OF PAYMENT:

The unit price bid for each LED Blankout Sign shall include the cost of furnishing all labor, materials, tools and equipment necessary to complete the work. Payment for all brackets and hardware required for sign support and attachment, all cabling, conduits and surge protection per the plans, documentation, testing referenced herein, operational support equipment and all other necessary material shall be included under this bid item. Payment for sign structure or mounting posts shall be included under other contract items.