1062 - ARTERIAL DYNAMIC MESSAGE SIGNS

1062.1 DESCRIPTION

a. Work

The Contractor shall furnish all labor, equipment and materials to install arterial dynamic message signs (DMS) and all equipment and wiring necessary for sign installation at the locations shown on the plans, in conformance with the details, and the material specifications included herein. Unless specifically noted otherwise, all DMS equipment shall be new and similar to the best grade of this type of equipment, and shall be approved by the Engineer.

The dynamic message sign system shall be complete, and the Contractor shall furnish and install all equipment necessary for the satisfactory operation of electrical apparatus and for the complete operation of the dynamic message sign system whether specifically mentioned or not.

Equipment to be furnished at each DMS field site shown in the plans shall include, but not be limited to the LED Variable Message Sign (VMS), sign controller, cabling and opto-coupled interface from controller to sign. Equipment to be furnished at the DMS central site, if called for in the plans, shall include but not be limited to central controller with, and modems.

b. Plans

The plans that accompany these specifications shall be considered a part thereof. Whenever any part of the plans shall be in conflict with any other part or parts of the plans, or any part of these specifications shall be in conflict with any other part or parts of these specifications or any of the items proposed to be constructed shall appear to be impracticable, or impossible to construct, then the matter shall be immediately brought to the attention of the Engineer or his agent. The Engineer's decision in the matter shall be final, and the Contractor shall follow his directions to avoid any such conflict in the plans or specifications.

All incidental parts which are not shown on the plans or specified herein and which are necessary to complete arterial dynamic message signs shall be furnished and installed as though such parts were shown on the plans or specified herein. All systems shall be complete and in operation to the satisfaction of the Engineer at the time of acceptance of the work.

All appurtenances shall be located as shown on the plans and shall conform to line, elevation and grades as shown on the plans. Any deviations must be established by the Engineer in the field. The Contractor shall have a copy of the plans and specifications at the job location at all times and accessible to the Engineer or his authorized representative. Prior to the acceptance of the work, the Contractor shall submit an "As Built" or corrected plan showing in detail all construction changes, especially location and depth of conduit.

c. Terminology

Due to the varying definitions used in Variable Message Sign technology, this section defines specific terms as they apply to this specification.

(1) Sign: The sign housing and its contents

(2) Sign Controller:

Located in a ground cabinet, the sign controller specifies the message to be displayed. Messages can be selected remotely from the central controller, locally from a laptop computer or from the front panel of the sign controller

(3) Central Controller:

The MS Windows NT Server computer system and related software which operates the system from a remote control site.

(4) Dynamic Message Sign:

Any sign system that can change the message presented to the viewer such as VMS, CMS and BOS. It includes the following major components: sign face, sign housing, controller and, if present, the controller cabinet. Abbreviated DMS.

(5) Variable Message Sign:

A type of DMS, which allows a user to create and download the message to be displayed into the temporary memory area of the sign controller. Abbreviated VMS.

(6) Laptop Computer:

This computer can operate both as a remote client to the central controller and/or a maintenance terminal at the sign controller. In its maintenance terminal operation, an operator can connect the laptop computer to the sign controller and run diagnostic tests on the sign or select and program messages for that sign. In its remote client operation, an operator can dial-in to the central controller and gain full access to the functions of the central.

(7) Workstation:

This computer operates as a remote client to the central controller. A workstation operator can dial-in to the central controller and gain access to the functions of the central by using the appropriate access codes.

(8) LED: Light Emitting Diode

(9) Pixel:

Any of the small discrete elements that, when arranged in a pixel matrix, create a character. A pixel contains a cluster of LEDs.

(10) Pitch:

Distance measured from center to center of adjacent pixels within a matrix. This distance is measured both horizontally and vertically.

(11) Poll:

The central controller and laptop computer are said to "poll" a sign when they request the sign's status information. The term is derived from the periodic status polling which a central can perform, but is loosely used to refer to any status request.

(12) Message: Text; the information shown on the sign.

(13) Display:

The message seen by the motorist. A display may include more than one page of text (an alternating display). Any character or set of characters of a display may be flashed (a flashing display).

(14) Neutral State:

Sign is blank, or displaying a predefined message that is displayed regularly.

(15) WYSIWYG:

What You See Is What You Get. In this specification, this is the functionality of the LED VMS system where the central, workstation or laptop display mimics the actual message that is visibly displayed on the sign on an individual pixel basis.

d. Regulations and Code

All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA). In addition to the requirement of these specifications and the plans, all material and work shall conform to the requirements of the National Electrical Code (NEC), the Standards of the American Society for Testing Materials (ASTM), the American Standards Association (ASA), and local ordinances. Requirements of Underwriters' Laboratories, Incorporated shall be followed for all items installed where applicable. Pertinent requirements of the local utility company shall be followed. Wherever reference is made in these specifications or in the standard provisions to the code, the safety orders, the general order, or the standards mentioned above, the reference shall be construed to mean the code, order, or standard that is in effect at the date of advertising of these specifications.

e. Qualifications of Installers

For the actual fabrication, installation, and testing of the work of this Section, use only thoroughly trained and experienced personnel who are completely familiar with the requirements for this work and with the installation recommendations of the manufacturers of the specified items. In acceptance or rejection of installed electrical system, no allowance will be made for lack of skill on the part of installers.

f. Preliminary Schedule of Equipment and Material

Prior to commencement of construction activities, the Contractor shall submit a complete schedule of materials and equipment proposed for installation for the approval by the Engineer. This schedule shall include catalog cuts, diagrams, drawings, and other such descriptive data as may be required by the Engineer. Any item not listed on the Approved Manufacturer's List shall also require the submittal of catalog cuts, diagrams, drawings, technical specifications, and a physical sample of the item for evaluation by the Engineer. In the event any items of material or equipment contained in the schedule fail to comply with specification requirements, such items may be rejected.

g. Rejected Materials

Rejected materials shall be immediately removed from the project site by the Contractor and shall not again be brought upon the project site. Work shall be commenced and continued at such points as may be approved by the Engineer and shall be carried on diligently and without unnecessary or unreasonable delay.

h. Coordination with Existing Utilities

All existing conduit/conductor runs and other utility information were obtained from existing office records. It shall be the Contractor's responsibility to locate all utilities, whether above, on, or below the ground, and to protect the City against any and all damages arising from work under this project.

No new infrastructure shall be constructed as part of this contract which is in conflict with any existing utilities' facility or the code required thereby, unless approved by the Engineer

i. Notification

The Contractor shall notify the Engineer before beginning work on the project. The Contractor shall keep the Engineer advised as to the progress of the project and the Contractor's proposed schedule. The Engineer may, at their option, require any work completed without their knowledge or inspection to be dismantled and inspected to their satisfaction. The contractor shall notify each property owner at least one day in advance of construction activity being started in front of the respective property.

j. Protection of Work and Cleanup

The Contractor shall care for all work until final completion and acceptance by the City. All damage done to existing improvements by the Contractor shall be repaired by the Contractor. The Contractor shall remove all surplus material and rubbish from the work as it accumulates and before the Contractor makes application for the acceptance of the work.

1062.2 MATERIALS

Unless specifically noted otherwise, all materials and equipment shall be new and similar to the best grade of this type of equipment, and shall be approved by the Traffic Engineer. The Contractor shall install all of the equipment and cabling necessary for an operational system as indicated on the plan and in accordance with this specification. The Contractor shall furnish and install all equipment necessary for the satisfactory operation of the system in accordance with this specification whether specifically mentioned or not.

a. Approved Materials List

All material for arterial dynamic message signs used by the Contractor shall be from the City's approved list of vendors. It is important that users be completely knowledgeable of all application requirements and procedures prior to product application. It is the responsibility of the installer to contact the supplier of all materials if questions regarding application procedures or conditions arise.

Manufacturers interested in pre-qualifying material under this specification shall submit a sample of the material along with a complete materials specification for each item to be considered. The sample will be reviewed for compliance with all requirements of this specification. No material shall be used unless the material has been pre-qualified. A complete list of pre-qualified materials is maintained by the Traffic Services Engineering Division of the Department of Public Works.

b. LED Variable Message Sign (VMS)

The LED VMS shall enable the display of text, consisting of a string of alphanumeric and other characters. Each character shall be formed by a matrix of luminous pixels. The matrix of a standard

character shall consist of 35 pixels over 5 columns and 7 rows. All display elements and modules shall be solid state. No mechanical or electromechanical elements or shutters shall be used. Dimensions of the VMS shall not exceed 4.5’ (54 inches) tall by 12.5’ (150 inches) long. The front to back housing depth shall not exceed 3.0’ (36 inches) at its widest point, including rear ventilation hoods. Other dimensions and configuration details of the sign covered by this specification, can be seen in Table 1 below:

TABLE 1: SPECIFIC SIGN DIMENSIONS / REQUIREMENTS	
Sign type:	Lift-Face
Matrix type:	Full
Nominal character height:	8”
No. lines:	3
LED manufacturer / part number (if applicable):	Agilent / HLMP-EL17
LED color / wavelength:	Amber / 590 *n*m
LED viewing angle:	30°
LED pixel brightness:	8 Candela @ 20mA
Pixel pitch:	1.25”
Pixel diameter:	.5”
Pixel layout: Display (H x W): Display Module (H x W): **Display Module Layout (H x W):**	 28 x 110 (full matrix) 14 x 10 2 x 11
Characters per line Optimum: Maximum:	 16 22
Power consumption range:	2 - 12 A (@120VAC)
Width (H x W):	12' 4½"
Height:	45¼“
Depth:	23”
Approximate weight range:	730 - 840 lbs

(1) General

All materials furnished, assembled, fabricated or installed under this item shall be new, corrosion resistant and in strict accordance with the details shown in the plans and as detailed in this specification. All details and functionality listed in this specification will be thoroughly inspected and tested by the City. Failure to meet all details and functionality detailed in this specification shall be grounds for rejection of the equipment.

The equipment design and construction shall utilize the latest available techniques with a minimum number of different parts, subassemblies, circuits, cards and modules to maximize standardization and commonalty. The equipment shall be designed for ease of maintenance. All component parts shall be readily accessible for inspection and maintenance. Test points shall be provided for checking essential voltages.

- The sign shall be designed for a minimum life of 20 years.
- The sign shall be designed and constructed so as to present a clean and neat appearance. Poor workmanship shall be cause for rejection of the sign.
- All cables shall be securely clamped/tied in the sign housing. No adhesive attachments will be allowed.
- The VMS, including the sign housing and all modules and assemblies, shall be designed and manufactured in the USA. To ensure proper service, support and logistics, US-based VMS service and support personnel are required. The bidder shall certify that it will comply with the requirements of Section 1048 of the Intermodal Surface Transportation Efficiency Act of 1991 and Regulations in 49 CFR 661
- The complete sign housing shall be designed and manufactured in-house by the LED VMS Sign Manufacturer.
- The sign housing shall be designed to AASHTO and NCHRP Reports 411 and 412 for winds up to 120 MPH with a 30% gust at 30 feet above grade for dead, ice, and wind loads and additionally a 40 lb/sq ft snow load and a 600 lb live load.
- The performance of the sign shall not be impaired due to continuous vibration caused by wind, traffic or other factors. This includes the visibility and legibility of the display.
- The VMS hardware, along with the sign controller hardware, software and firmware, shall support all VMS functionality described throughout the remaining specification sections.

The VMS assembly shall be listed by an accredited 3rd party testing organization for conformance to Underwriters Laboratories (UL) standards 48 (Standard for Electric Signs) and 1433 (Control Centers for Changing Message Signs). Proof of this conformance shall be provided with submittal materials.

(2) Electronic Materials and Components

All electronic components, except printed circuit boards, shall be commercially available, easily accessible, replaceable and individually removable using conventional electronics repair methods.

All workmanship shall comply with IPC-A-610C, Class 2 titled "Acceptability of Electronic Assemblies", ANSI/IPC-7711 titled "Rework of Electronic Assemblies" and ANSI/IPC-7721 titled " Rework and Modification of Printed Boards and Electronic Assemblies." All electronic components shall comply with Section Electronic Materials and Construction Methods, located in this document.

(3) Printed Circuit Boards

Printed Circuit Board (PCB) design shall be such that components may be removed and replaced without damage to boards, traces or tracks. Only FR-4 0.062 inch minimum thickness material shall be used. Inter component wiring shall be copper clad track having a minimum weight of 2 ounces per square foot with adequate cross section for current to be carried. Jumper wires will not be permitted, except from plated-through holes to component. The maximum number of jumper wires allowed per circuit board is two.

All Printed Circuit Boards (PCBs), except for the LED display board, power supply PCBs and controller PCBs, shall be completely conformal coated with a 0.010 inch (10 mil) minimum thickness silicone resin conformal coat. The LED display boards shall be completely conformal coated, except at the pixels on the front of the PCB, with a 0.010 inch (10 mil) minimum thickness silicone resin conformal coat. The material used to coat the PCBs shall meet the military specification: MIL-I-46058C Type SR and IPC-CC-830. Acrylic conformal coating will not be accepted. All PCBs shall be finished with a solder mask and a component identifier silk screen.

(4) Components

All components shall be of such design, fabrication, nomenclature, or other identification so as to be purchased from a wholesale electronics distributor, or from the component manufacturer, except for printed circuit board assemblies. Circuit design shall be such that all components of the same generic type, regardless of manufacturer, shall function equally in accordance with the specifications. All discrete

components, such as resistors, capacitors, diodes, transistors, and integrated circuits shall be individually replaceable. Components shall be arranged so they are easily accessible for testing and replacement.

(a) Capacitors

The DC and AC voltage ratings as well as the dissipation factor of a capacitor shall exceed the worst case design parameters of the circuitry by 50%. A capacitor which can be damaged by shock or vibration shall be supported mechanically by a clamp or fastener. Capacitor encasements shall be resistant to cracking, peeling and discoloration.

(b) Resistors

Resistors shall be within 5% of tolerance over the specified temperature range. Any resistor shall not be operated in excess of 50% of its power rating.

(c) Semiconductor Devices

All transistors, integrated circuits, and diodes shall be a standard type listed by EIA and clearly identifiable.

(d) Connectors

All display circuits PCB edge connectors and cable connectors shall be base plated with nickel and finished with 30 micro-inches of gold.

(5) Mechanical Components

All external screws, nuts, and locking washers shall be stainless steel. No self-tapping screws shall be used. All parts shall be made of corrosion resistant materials, such as plastic, stainless steel or aluminum. All materials used in construction shall be resistant to fungus growth and moisture deterioration. Dissimilar metals shall be separated by an inert dielectric material.

(6) Modes of Operation

The mode of operation determines which level of control governs the VMS message selection. The three modes of operation are:

- Central Mode: The local control panel switch is off and the central controller controls and monitors the sign.
- Local Mode: The local control panel switch is on and the laptop computer or front panel of the sign controller is used to locally control the sign. The central controller only monitors the sign (i.e. status poll).
- Local Override: The local mode has been overridden by the central to allow the central to control the sign in case the local control panel switch was unintentionally left in local mode

(7) Environmental Behavior

The VMS shall be capable of operating without any decrease in performance over a temperature range of -40°F to 165°F with a relative humidity of up to 95% non-condensing, unless otherwise noted in this specification.

(8) Lift-Face Housing

The lift-face housing dimensions and total weight shall be as shown in this specification or in the plans. The lift-face housing shall be designed and manufactured to be rain and weather tight. The sign housing skin shall be constructed of aluminum alloy 5052-H32 which shall not be less than 1/8" thick, unless otherwise specified in this document. Framing structural members shall be made of aluminum alloy 6061-T6. The equipment within the sign housing shall be protected from moisture, dust, dirt and corrosion. The lift-face housing shall meet NEMA 3R enclosure criteria as defined in NEMA Standards Publication 250-1997, "*Enclosures for Electrical Equipment (1000 Volts Maximum).*"

(a) Surface Finish

The face (lens panel aluminum mask) will be finished with a matte-black, licensed-factory-applied, KYNAR 500 Resin, fluropolymer-based coating system. The face shall be uniform in appearance and completely free from distortion, gouges and any other flaws or defects. A certification shall be required from the licensed-factory KYNAR 500 coater for all aluminum face materials. All other exterior surfaces will be painted with a semi-gloss, Flint Gray Texture finish color chip number T243-GR522 by Cardinal Industrial Manufacturing. All interior surfaces will be a natural aluminum mill finish.

(b) Welding Requirements

All welding shall be by an inert gas process in accordance with the American Welding Society (AWS) Standards, 2003 ANSI/AWS D1.2/D1.2M Structural Welding Code for Aluminum. The LED VMS manufacturer's welders and welding procedures shall be certified by an ANSI/AWS Certified Welding Inspector to the 2003 ANSI/AWS D1.2/D1.2M Structural Welding Code for Aluminum. Proof of certification of all the LED VMS manufacturer's welders and applicable welding procedures shall be supplied with the submittals. The name, phone number and address of the ANSI/AWS Certified Welding Inspector that certified the LED VMS manufacturer's welders and procedures shall also be provided with the submittals.

(c) Exterior Skin

The exterior skin of the housing will be 5052-H32 aluminum alloy sheet 0.125 inches minimum thickness. The number of seams shall be kept to a minimum. All exterior seams and joints shall be sealed to form a rain and weather tight enclosure. All exterior seams shall be continuously welded by an inert gas process, except for the KYNAR 500 coated fascia material. The skin material shall be stitch welded to the internal structural members to form a unitized structure.

(d) Internal Structure

The interior structural members shall be 6061-T6 aluminum alloy extrusions.

(e) Mounting

The housing shall be designed to accommodate mounting on the rear vertical plane. The exterior mounting assemblies shall be 6061-T6 aluminum alloy extrusions, 3/16-inch minimum thickness.

(f) Housing Face

The housing face will be of a two piece construction, consisting of internal structural members and lens panel assemblies. The border from the display area to the edges of the sign shall be a minimum of 5.3 inches.

(g) Internal Structural Members

The Internal Structural Members shall accommodate both display module mounting and air distribution and retain the display modules in a manner to facilitate easy and rapid removal of each display module without disturbing adjacent display modules.

(h) Drain Holes

The bottom panel of the housing shall have a minimum of four drain holes, with snap-in, drain filter plug inserts, in each section formed by internal structural members. Water drain filter plug inserts shall be replaceable.

(9) Lens Panel Assembly

The Lens Panel Assembly shall consist of a KYNAR 500 coated aluminum mask over a clear glazing. The aluminum mask shall be laminated and sealed to the surface of the glazing using the 3M Scotch VHB joining system or pre-approved equivalent. The Lens Panel Assembly shall be sealed with a closed-cell resilient gasket.

(a) Lens Panel Mask

The Lens Panel Aluminum Mask shall be 0.090 inch minimum thickness, finished with a matte-black, licensed-factory-applied, KYNAR 500 Resin, fluropolymer-based coating system. The panel shall be perforated to provide an aperture for each pixel on the display modules. Each aperture shall be as small as possible, without blocking the LED light output at the required viewing angle.

(b) Glazing

The Lens Panel Clear Glazing shall be 90% UV opaque polycarbonate – GE LEXAN® XL10 or pre-approved equivalent. The required glazing shall be 1/8-inch thick minimum, clear in color and be guaranteed for 10 years against yellowing, loss of light transmission and breakage. The properties shall also include:

- Tensile Strength, Ultimate: 9,500 psi
- Tensile Strain at Yield: 6%
- Tensile Modulus: 340,000 PSI

- Flexural Modulus: 340,000 PSI
- Impact Strength, Izod (up to 125 mils, notched): 12-16 ft-lbs/inch
- Rockwell Hardness: M70, R118
- Heat Deflection Temperature Under Load: 270°F (264 psi); 288°F (66 psi)
- Coefficient of Thermal Expansion: 3.75x10-5 in/in/°F
- Initial Light Transmittance: 88% (average)
- Change in Light Transmittance, 5 years exposure: less than 5%
- Change in Yellowness Index, 5 years exposure: less than 5%

(c) Accessibility

The sign housing shall be front access. The sign housing shall be provided with a single lift-face door for accessibility to all internal components of the sign. A sign with multiple access doors is not acceptable. The sign shall have two fixed-force gas springs that easily open the lift face and hold it open at any position from closed to 60 degrees open. The face shall be easily opened from a bucket truck by a single person. Regular opening and closing of the lift face shall not cause warping or misaligned fit/closure. A stainless steel hinge shall connect the sign housing and the lift face. All components shall be readily accessible for maintenance when the lift face is open. Gaskets shall provide a weather-tight seal when the lift face is closed. A minimum of two closure devices shall be used to secure the lift face to the sign housing. A hasp that is lockable with a padlock shall be provided near one of the closure devices.

(d) Internal Lighting and Electrical Outlets

The sign housing shall be furnished with a minimum of two incandescent lamps and one unused GFI duplex outlet. There shall be a door switch for the lights. The lights shall be enclosed in heavy-duty fixtures. Each fixture shall have a die-cast aluminum housing, a twist-on guard secured by four set screws and a porcelain socket. There shall be a clear glass globe inside the twist-on guard. The globe shall be gasketed and fully enclose the lamp.

(10) Environmental Control

The housing shall include a ventilation system with an intake and exhaust system as specified below.

(a) Ventilation System

The ventilation system shall be a positive-pressure, filtered, forced-air system which cools both the display modules and the sign housing interior. Signs with negative pressure systems that use exhaust fans are not acceptable. All duct work that impedes access to any sign components shall be easily removable, without tools, for servicing of these components. All ductwork shall be 0.040-inch thickness aluminum and shall be designed to be efficient with minimal pressure drop throughout the system.

(b) Ventilation system Intake / Exhaust

The ventilation system shall have a minimum of one fan. The fan shall be located on the intake side to produce a positive pressure system. Air shall be drawn into the sign housing through a hood near the top of the housing, then filtered before reaching the fan unit. There shall be an aluminum air plenum that contains the intake fan and filter.

The fan shall be capable of providing a minimum of one sign housing volume change per minute at the pressure drop developed throughout the entire ventilation. The fan shall have ball or roller bearings, shall be permanently lubricated and shall require no periodic maintenance. The fan is to be positioned in such a manner so as to provide a balanced air flow to the ventilation system.

The sign housing shall have one exhaust port. The exhaust port shall be filtered and protected by an aluminum hood assembly. There shall be an aluminum air plenum for the hood assembly and its associated filter. The air plenum will be sealed and designed to keep any water that gets through the hood from getting into the sign housing interior. All water that builds up between the hood and the filter shall drain to the exterior of the sign housing.

(c) Ventilation System Intake / Exhaust Filters

The inlet and exhaust filters shall be electrostatic and shall be sized to properly accommodate the air flow and pressure drop requirements of the ventilation system. The filters shall have an Initial

Minimum Efficiency Rating Value (MERV) of 7 in accordance with ASHRAE 52.2p. Filters shall be easily removable from within the sign housing without the use of tools. Both inlet and exhaust shall use environment-friendly, washable, reusable electrostatic filters.

(d) Defog / Defrost

The lens panel shall be heated to prevent fogging, frost and condensation. An eight watt-per-foot, self-regulating, heat tape shall be located along bottom of the message area, between the glazing and the display modules. The heat tape shall be controlled by the sign controller. All heat tape terminal blocks shall be covered for safety.

(11) Optical and Electrical Characteristics

The optical and electrical components shall meet the following specifications.

(a) LED and Pixel Characteristics

The LED's shall be AlInGaP, Precision Optical Performance T 1-3/4 diodes as specified in Table 1 with a 30 degree viewing angle. The cone perimeter shall be defined by its 50% intensity points. The LED's shall have standoffs that hold the base of the LED's 3.5mm + 1.0mm off the printed circuit board to promote cooling of the LED's. Through-hole LED's mounted flush to the printed circuit board are not acceptable. Surface-mount LED's are not acceptable.

Pixel brightness shall be attained by the sum of the brightness of the individual LED's in each pixel. The brightness of each LED shall be measured in accordance with the CIE Test Method A, as described in CIE 127-1997, Technical Report: Measurement of LED's. The LED brightness and color bins that are used in each pixel shall be provided to the engineer for approval.

Certification shall be provided, with the submittals, from the LED manufacturer that demonstrates that the LED's were tested and binned in accordance with the CIE Test Method A. The LED's in each pixel shall be clustered to maximize long range visibility. All pixels shall have equal color and on-axis intensity. All pixels in all signs in this project, including the spare parts, shall have equal color and on-axis intensity. The method used to provide the equal color and intensity, as stated above, shall be included in the submittals and approved by the Engineer.

Each pixel shall contain two strings of LED's. The pixel strings shall be powered from a regulated DC power source and the LED current shall be maintained at 28 milliamperes or less per string to maximize life of the pixel. The failure of an LED in one string within a pixel shall not affect the operation of any other string or pixel. Pixel power drawn from the DC supplies shall not exceed 1.5 watts per pixel, including the driving circuitry. The LED's shall be individually mounted directly to a printed circuit board and shall be easily replaceable and individually removable using conventional electronics repair methods.

(b) Display Modules

Each display module consists of a display board with a matrix of LED pixels and its associated driver board. The pixels are mounted on the front side of the display module. Each driver board controls up to nine display modules. The driver board connects to the sign interface circuits and passes information to the associated display modules, which control the character pixels. The driver board shall receive control signals and display data directly from the sign controller. The display module shall contain the control and memory elements and provide the signals to switch and read the LED pixels.

The LED display board shall contain all LED's required to form a matrix of pixels. The height and width of this pixel matrix is specified in Table 1. Pixels shall be arranged uniformly to display a dot-matrix character of the desired height and width in five columns wide and seven pixels high. The character height shall be defined as the distance from the lowest point of the lowermost pixel of the character to the highest point of the uppermost pixel of the character. The display modules shall be rectangular, and shall have an identical horizontal and vertical pitch between pixels.

The separation between the last column of one module and the first column of the next shall be equal to the horizontal distance between the columns of a single display module. The separation between the last row of one module and the first row of the next shall be equal to the horizontal distance between the rows of a single display module. All LED's shall be individually and directly mounted to the LED

circuit board to form the LED display board. The LED circuit board shall be a single, 0.062 inch, FR4, flat black printed circuit board. The LED display board shall support the driver board.

All LED's shall be mounted so that their mechanical axis is normal +/- 1.00 degree to the face of the sign to ensure brightness uniformity over the face of the sign. The sign manufacturer shall propose a method, acceptable to the engineer, to test the LED's in the display modules to ensure they meet these criteria.

(c) Pixel Protection Device

Each pixel shall have a device attached to the printed circuit board (PCB) to hold and protect the LED's. These devices shall:

- Hold the LED's perpendicular to the display modules within 0.5 degree
- Prevent the LED's from being crushed or bent during handling
- Protect the LED's from damage when the display module is laid on the front surface (the side that the LED lamps are located)
- Be easily removable from the display module PCB without any tools
- Not put any stress on the LED's due to differentials of expansion and contraction between the device and the LED's over the herein specified temperature range
- Not become loose or fall off during handling or due to vibrations
- Not block airflow over the leads of the LED's
- Securely hold each LED while allowing a gap between the device and a minimum of 95% of the body of each LED for airflow
- Not block the light output of the LED's at the required viewing angle
- Be black in color to maximize contrast

The driver boards shall connect to a single control cable common to each line of display modules. Epoxy encapsulation of the LED's will not be permitted. Hoods or visors shall not be used. The LED's shall be protected from the outside environmental conditions, including moisture, snow, ice, wind, dust, dirt and UV rays.

(d) Display Assembly

Display modules shall be assembled to achieve the matrix and line configuration specified in Table 1. For full- and line-matrix configurations, the optimized number of characters per line is achieved with a double pixel column between any two adjacent characters. Each display module shall include an LED display circuit board. A piggyback driver board shall attach directly to its associated LED board. The driver board shall contain the solid state electronics necessary to control pixel data and read pixel status. All LED boards and driver boards shall be fully interchangeable and shall not require any manual addressing switches or adjustment when interchanged or placed in service. Replacement of a complete display module shall be possible without the use of any tools.

(e) Legibility

The characters shall be legible under all light conditions at a distance of 450 feet within the degree cone of vision centered around the optical axis of the pixel. The cone perimeter shall be defined by its 50% intensity points. The sign shall be the proper brightness in all lighting conditions for optimum legibility. It shall be bright enough to have a good target value, but not to the point where the pixels bloom, especially in low ambient light level conditions. The brightness and color of each pixel shall be uniform over the entire face of the sign within the cone of vision from 450 feet to 50 feet in all lighting conditions. Non-uniformity of brightness or color over the face of the sign under these conditions shall be cause for rejection of the sign.

(12) Sign Display Functions

The VMS shall be capable of the following display functions:

(a) Message Display

Display a message, including static messages, flashing messages, and alternating messages

(b) Flashing messages shall have the following adjustable timing:

- Message time on from 0.5 to 5.0 seconds in 0.1 second increments

- Message time off from 0.5 to 5.0 seconds in 0.1 second increment

(c) It shall be possible to flash any character or set of characters in any message.

(d) Alternating messages shall have the following adjustable timing:

- Primary message time on from 0.5 to 5.0 seconds in 0.1 second increments
- Primary message time off from 0 to 5.0 seconds in 0.1 second increments
- Alternate message time on from 0.5 to 5.0 seconds in 0.1 second increments
- Alternate message time off from 0 to 5.0 seconds in 0.1 second increments

(e) Character Flash

It shall be possible to flash any character or set of characters in an alternating message at the adjustable frequencies listed above for flashing messages. The flashing period shall be a sub-multiple of the alternating on-time it is associated with.

(f) Download Library

The sign controller shall also be able to accept a downloaded library from the central or laptop computer of a minimum of 25 changeable messages stored in non-volatile RAM. These messages may be called for display on the sign from the keypad on the front panel of the controller.

(g) Message Display from Non-Volatile Memory

The sign controller shall also be capable of displaying messages on the sign that are downloaded from the central controller or laptop computer, but are not located in the library stored in non-volatile memory of the sign controller.

(h) Characters

The signs shall be capable of displaying ASCII characters 32 through 126 (including all upper and lower case letters and digits from 0 to 9) at any location in a message line. If shown in the plans, a special graphics character shall be substituted for any of these characters.

(i) Character Spacing

The sign shall normally display single stroke (5 X 7) characters with double-column spacing between characters. The sign shall also be able to display compressed (4 X 7) or double-stroke (7 X 7) nominal character fonts or change the default spacing between characters. The spacing options shall be one, two or three pixel columns. Each font may be edited and downloaded to the sign controller from the central controller or laptop computer at any time without any software or hardware modifications.

(j) Pixel Status Read

There shall be no perceivable blinking, flickering or ghosting of the pixels at any time, except during a pixel test as described above. The displayed message will not be affected in any way at any time for the pixel status read as described above.

(k) Self-Updating Messages

The sign controller shall be able to put a self-updating time, temperature and/or date display on the sign.

(l) Moving Arrow Board

The sign controller shall allow a moving arrow to be displayed by the central controller or laptop computer. The moving arrow shall be on one line with a standard message on the other lines. The moving arrows shall be from the left or right and shall start from one end or in the middle of the sign and continue to the end of the sign.

(13) LED DC Power Supply

The power supply shall meet the following specifications

(a) Power Supply

The voltage to the LED modules and associated electronics shall not exceed 25 VDC. Functioning supplies must current-share to within 10%. The combined effect of line (97 to 135 VAC) and load (10% to 100%) on the power supplies shall not exceed 1.0%. The efficiency of the power supplies shall have an efficiency of 75% (typical).

(b) Display Intensity Variation

There shall be a power distribution system that connects each display module to all power supplies and minimizes the voltage drop over the face of the sign. The voltage measured at the display modules shall not vary more than 50 millivolts over all the display modules in the sign with 17 pixels on at 100% intensity in each and every display module.

(14) Automatic Brightness Control

The VMS shall be capable of automatically adjusting LED brightness to account for changing ambient light conditions. The system required for this function consists of three primary component groups: Photocells, an adjustable brightness table and the overall brightness capability of the VMS

(a) Photoelectric Sensor Devices

Three (3) photocells shall be installed on the sign. These devices shall permit automatic light intensity measurement of light conditions at each sign location. These photocells shall be mounted in a manner to measure front, rear and ambient light conditions.

(b) Brightness Table

The sign controller shall monitor the photo cell circuits in the sign and convert the measured light intensity into the desired pixel brightness. The photo circuit readings shall be correlated with a brightness table in the sign controller. The brightness table shall have a minimum of 256 brightness levels. Each sign shall have its own, independent brightness table. The brightness table in each individual sign controller shall be locally downloadable and can be customized according to the requirements of the installation site

(c) Sign Brightness Capability

Automatic adjustment of the LED brightness shall occur in small enough increments so that the brightness of the sign changes smoothly, with no perceivable brightness change between adjacent levels. Provision shall be made to prevent perceivable brightening of the sign due to stray headlights shining upon the photo sensors at night.

Pixel brightness shall be controlled by pulse width modulation of the DC current. The pixel current waveform shall have a frequency of l00 +/- 5 Hz at nighttime brightness levels and greater than 1600 Hz at daytime brightness levels with an adjustable duty cycle of 0.03 to 99.9% in 0.5% or finer increments.

There shall be a means to adjust how rapidly the sign responds to changes in ambient light as measured by the photocells. This can be used, for example, to prevent the sign from changing its brightness due to a vehicle’s headlight momentarily hitting the sign. The adjustment shall be made from the central controller or laptop computer and shall have two different settings, one for daytime control and one for nighttime control, with the day/night ambient light threshold also being an adjustable value. In addition, there shall be a means to specify different weighting factors for each photocell, to specify how prominently each photocell figures in the calculation of nighttime ambient light.

(d) Manual Brightness Control

Brightness shall be manually settable from the front panel of the controller and remotely from the central computer in 1% increments from one to 99 percent. Brightness control shall be able to be returned to automatic from the sign controller front panel and the central computer.

(15) Pixel Status Feedback

Pixel status feedback shall be provided to the central controller from the local sign controller and shall include the following:

(a) Pixel Test

The pixel test shall be performed from the central controller on command and automatically once a day. During a pixel test, the full operational status of each pixel shall be tested and then transmitted to the central controller or laptop computer. This pixel status test shall distinguish the difference between full out and fully stuck-on pixels. A list of defective pixels shall be provided, listing pixel status, line number, module number, column number and row number for each defective pixel. The pixel test must be completed in less than 0.5 seconds, regardless of message status.

(b) True Message Legibility Verifications (TMLV)

The TMLV shall return the state of each pixel to the central controller as it is currently displayed to the motorist, including any errors. The TMLV shall be an actual real time read of the current flowing through each string of LED's at the time of the associated sign poll or message download and shall not be accomplished by simulating errors based on the last pixel test. This shall allow the central controller operator to see what is visibly displayed to the motorist on an individual pixel basis.

The TMLV shall be performed during both message downloads and during every sign poll from the central controller or laptop computer. During a TMLV, the state of each pixel (full-on or off) in the sign shall be read by the sign controller to allow the central controller or laptop computer to show the actual message, including static, flashing and alternating messages, that is visibly displayed on the sign in a "what you see is what you get" (WYSIWYG) format. This pixel verification shall take place while a message is displayed on the sign without disturbing the message in any way. Any flashing, flickering, blinking, dimming, or other disturbance of the message during this pixel read shall be cause for rejection of the sign.

(16) AC Power

The sign and its sign controller shall be capable of operating with 120/240 VAC, 30 A per leg, 60 Hz, single-phase power. Inside the sign housing, all 120 VAC service lines shall be independently protected by a thermo magnetic circuit breaker at the sign housing entry point. All 120 VAC wiring shall be located in conduit, pull boxes, raceways or control cabinets as required by the National Electric Code (NEC). No 120 VAC wiring shall be exposed to the inside or outside of the sign housing. The sign housing shall not be considered as a raceway or control cabinet.

The presence of power transients or electromagnetic fields, including those created by any components of the system, shall have no deleterious effect on the performance of the system. The system shall not conduct or radiate signals which will adversely affect other electrical or electronic equipment including, but not limited to, other control systems, data processing equipment, audio, radio and industrial equipment.

The sign shall have a 30 A two-pole (common trip) main, 120/240 VAC, single phase, four wire load center with 16 circuit capability. Each circuit in the sign shall be powered from a separate circuit breaker. In the event of a power failure, the sign controller shall activate a programmable default message (which can be a blank message) and shall report the AC power failure to the central controller.

(17) Surge Protection

The system power shall be protected by two stages of transient voltage suppression devices including MOVS and spark gap arrestor. Tripping of each stage (or both if tripped simultaneously) of the surge protection shall cause the sign controller to call central and report the error condition (for dialup operation) or report the error condition to central on the next poll (for multi-drop operation). There shall be an option that is either enabled or disabled and is selected and downloaded from the central controller to the sign controller. When this option is enabled, tripping of both stages of surge protection shall prevent power from reaching any components of the sign until the surge protection has been replaced. When this option is disabled, the sign will continue to function normally after both stages of surge protection are tripped.

Communication lines shall be protected by two stages of transient voltage suppression devices including MOVS and spark gap arrestor. Tripping of each stage (or both if tripped simultaneously) of the surge protection shall cause the sign controller to call central and report the error condition (for dialup operation) or report the error condition to central on the next poll (for multi-drop operation). There shall be an option that is either enabled or disabled and is selected and downloaded from the central controller to the sign controller. When this option is enabled, tripping of both stages of surge protection shall disconnect the communication lines until the surge protection has been replaced. When this option is disabled, the sign will continue to function normally after both stages of surge protection are tripped.

(18) Sign Feedback and Monitoring Functions

The VMS, including sign hardware, controller firmware and controller software, shall be capable of performing the following functions:

(a) Report errors and failures, including:

- Power failure
- Power recovery
- Pixel failure

(b) Message and status monitoring:

The sign controller shall respond to the central controller whenever it receives a request for status (a poll). The return message shall be capable of providing the following information:

- Actual message that is visibly displayed on the sign on an individual pixel basis (full-on or off)
- Current sign illumination level
- Local Control Panel switch position (central, local or local override mode)
- Error and failure reports
- Origin of display message transmission (laptop, sign controller or central)
- Heat tape status

(c) Severe error condition response:

In dial-up mode, the sign controller shall initiate a call to the central controller and report any severe error conditions. In multi-drop mode, the sign controller shall report severe error conditions to the central controller during the next polling. The severe error conditions are:

- AC power failure
- AC power recovery

(d) Polling

Each time the sign controller is polled by the VMS Master Controller or laptop computer, the sign controller shall test the operational status of the sensors listed below and return this information to the VMS Master Controller. This operational status test shall determine if each photocell is functioning properly.

(e) Programmable Default Message

In the event the central controller fails to communicate with the sign controller within a programmable time limit, the sign shall activate a programmable default message (which can be a blank). This function shall apply only when the sign controller is in central control mode.

(f) Failure of any sign shall not affect the operation of any other sign in the system.

(g) Consistency Check

The sign controller shall perform a consistency check of messages downloaded from the central controller or laptop computer to ensure that the message will fit in the display area of the sign. If any part of the message fails this check, the downloaded message shall not be displayed.

(h) Internal Time Clock

The sign controller internal time clock shall ensure that a message is taken down at the correct time, even in the event of a communications loss.

(i) Internal Time Clock Maintenance

The sign controller shall maintain its internal time clock during power outages less than 255 minutes and display the proper message when power is restored.

(j) Auxiliary Outputs

The sign controller shall have a special function output bit to control an auxiliary blank-out sign. This shall be a closure to ground capable of sinking at least 10 mA. It shall be controlled from the central controller.

(k) The sign controller shall be capable of being remotely reset from the central controller.

(19) Transient Test Requirements

The sign housing electronics and the control cabinet shall be separately capable of withstanding a high-energy transient having the following characteristics repeatedly applied to the AC input terminals:

A ten microfarad oil filled capacitor charged to 1000 VDC ±5% shall be discharged into the power input terminals a minimum of three times for each polarity. Immediately following this test the unit under test shall perform all of its defined functions upon the restoration of normal AC power.

(20) Sign Manufacturer and Fabrication Requirements

The equipment manufacturer shall be held to the following requirements:

(a) ISO 9001:2000 Requirements

The company that designs and manufactures the LED VMS shall be currently ISO 9001 certified as of the bid date for this project and shall have received its ISO 9001 certification a minimum of **five** years prior to the bid date for this project. The scope of this company's ISO 9001 certification shall be for the Design, Manufacture, Installation, Maintenance and Sales of Variable Message Sign Systems. The facility where this company actually designs and manufactures the LED VMS shall be ISO 9001 certified. This company, this scope and the address of this facility shall all be listed on the ISO 9001 certificate. This ISO 9001 certificate shall be provided with the bid. The name, phone number and address of both the Authorized ISO 9001 Registrar that certified this company and the Authorized ISO 9001 Accreditation Body that accredited this Registrar shall be provided with the bid. Failure to fully comply with these requirements and to provide all this information will cause this company's equipment and software to be rejected. ISO 9002 and ISO 9003 certifications are not adequate and do not meet this requirement

(b) Experience and Reference Statements

To be valid for these experience requirements, a LED VMS must be a State Highway, Interstate Highway or Major Arterial, permanently mounted, overhead, LED dynamic message sign with at least three lines of 8-inch minimum, 5x7 pixel, pure LED characters and minimum housing dimensions of 3.75 feet high by 12.3 feet wide. Non-LED VMS, hybrid VMS, lift-face VMS, non-highway VMS, portable VMS, indoor VMS, smaller VMS and commercial VMS will not satisfy these experience requirements.

As of the bid date for this project, the LED VMS Manufacturer shall have the following, all under the current corporate name.

- Ten (10) years' experience in the design and manufacture of State Highway or Interstate Highway, permanently mounted, variable message signs and central control systems installed in freeway service. These 10 years of experience shall include the complete design and manufacture of all aspects of the variable message signs, including the electronic hardware, software and sign housings.
- One hundred (100) LED VMS that are installed, successfully operating and owned by State Departments of Transportation for a period of no less than three (3) years.
- LED VMS that have been installed, successfully operating and owned by five (5) different State Departments of Transportation for a period of no less than five (5) years.
- One hundred (100) NTCIP-compliant LED VMS that are installed, successfully operating and owned by State Departments of Transportation. These NTCIP-compliant LED VMS must be permanently mounted, outdoor, roadway, LED VMS that are remotely controlled by an NTCIP compliant central computer.
- NTCIP-compliant LED VMS that are installed, successfully operating and owned by ten (10) different agencies. These agencies must be either State Departments of Transportation or City Public Works Departments. These NTCIP-compliant LED VMS must be permanently mounted, outdoor, roadway, LED VMS that are remotely controlled by an NTCIP compliant central computer.
- NTCIP-compliant DMS central control systems that are installed, successfully operating and owned by eight (8) different agencies. These agencies must be either State Departments of Transportation or City Public Works Departments. The software for the NTCIP-compliant DMS central control system must have been developed by the LED VMS manufacturer and must be a full featured, easy-to-use, 32-bit, robust, client-server Microsoft® Windows application that fully supports DMS operations and maintenance. For each agency, the NTCIP-compliant DMS central control server software must be the

primary DMS control and monitoring application, must simultaneously and remotely control and monitor multiple NTCIP-compliant signs, and must allow multiple clients to simultaneously and remotely connect to the server for sign control and monitoring.

- A LED VMS NTCIP-compliant system that has been installed, successfully operating and owned by a State Department of Transportation for a period of no less than two (2) years. This system must include an NTCIP-compliant DMS central control system and a minimum of ten (10) NTCIP-compliant LED VMS. The software for the NTCIP-compliant DMS central control system and the firmware for NTCIP-compliant LED VMS must have been developed by the LED VMS manufacturer and must have successfully passed an NTCIP test that was administered by an industry-accepted, independent company that was contracted by this State Department of Transportation to perform this test. The software for the NTCIP-compliant DMS central control system must be a full featured, easy-to-use, 32-bit, robust, client-server Microsoft® Windows application that fully supports DMS operations and maintenance. The NTCIP-compliant DMS central control server software must be the primary DMS control and monitoring application, must be installed on a server in the State Department of Transportation's traffic operations center, must simultaneously and remotely control and monitor multiple NTCIP-compliant signs, and must allow multiple clients to simultaneously and remotely connect to the server for sign control and monitoring.
- NTCIP-compliant LED VMS that successfully passed NTCIP tests that were administered by two (2) different, industry-accepted, independent companies that were each contracted by a State Department of Transportation to perform these tests.

The manufacturer of the LED VMS Signs and System shall submit documentary evidence and complete reference data for the above requirements. Reference data shall include the name and address of the organization, and the name and telephone number of an individual from the organization who can be contacted to verify the above requirements and all the details required to support the above requirements. The name of the VMS manufacturer that meets these experience requirements shall have the same corporate name as the VMS manufacturer that meets the ISO 9001 requirements stated elsewhere in this specification. This information shall be provided prior to documentation submittal. Failure to furnish the above references or meet the above requirements will be reason for rejection of the manufacturer's equipment.

The City reserves the right to contact additional references. Any poor or unsatisfactory reference, as determined by the City in its sole and absolute discretion, will cause the LED VMS manufacturer to be rejected.

(21) Sign Manufacturer and Fabrication Requirements

The following must be submitted for consideration and acceptance;

(a) As part of required submittal documentation, the manufacturer shall provide the following component cut sheets and certifications to the Engineer for review and approval:

TABLE 2: COMPONENT/FEATURE CONFORMANCE REQUIREMENTS	
Component or Feature	**Proof of Conformance**
Electrical Sign Safety:	• Accredited 3rd party certification of conformance to UL 48
Electrical Sign Control Center Safety:	• Accredited 3rd party certification of conformance to UL 1433

TABLE 2: COMPONENT/FEATURE CONFORMANCE REQUIREMENTS	
Component or Feature	**Proof of Conformance**
Sign Structural Integrity:	• Certification of conformance to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals (Third Draft)
All Electronic Components:	• Certification of conformance to ANSI/IPC-A-610C Class 2
PCB Silicone Conformal Coating:	• Certification of conformance to MIL-I-46058C Type SR • Certification of conformance to IPC-CC-830
Sign Controller:	• Component cut sheet certifying conformance to specification
Aluminum Welding:	• Proof of certification of all welders to ANSI/AWS D1.2/D1.2M-03 Structural Welding Code for Aluminum • Name, phone number and address of ANSI/AWS Certified Welding Inspector
Sign Housing / Local Control Cabinet Construction:	• Certification of conformance to NEMA Standards Publication 250
Lens Panel:	• Component cut sheet certifying LEXAN® XL10 or approved equivalent polycarbonate glazing • Component cut sheet certifying Lens Panel Aluminum-to-Glazing adhesive properties
Aluminum Fascia Panels:	• Certification from licensed coater of KYNAR 500® or equivalent ASCA '96-compliant Oven-Baked Polyvinylidine fluoride coatings
Sign Ventilation System:	• Manufacturer certification of conformance to specification • Component cut sheet verifying filter media conformance to specification
Sign Heating System:	• Component cut sheet certifying conformance to specification
LEDs / Display Modules:	• Component cut sheet certifying LED conformance to specification • Manufacturer certification of LED brightness testing Conformance to CIE 127-1997, Test Method A • Documentation identifying LED brightness and color bins used in each pixel • Manufacturer certification of character height measurement
Pixel Protection Device:	• Manufacturer certification of conformance to specification
LED Power Supplies:	• Component cut sheet certifying conformance to specification

TABLE 2: COMPONENT/FEATURE CONFORMANCE REQUIREMENTS	
Component or Feature	**Proof of Conformance**
Pixel Status Feedback:	• Manufacturer certification of conformance of Pixel Test feature to specification • Manufacturer certification of conformance of True Message Legibility Verification feature to specification
Quality Assurance:	• ISO 9001:2000 certification • Name, phone number and address of ISO 9001 Registrar • Name, phone number and address of ISO 9001 Accreditation Body
Transient Protection / Vibration:	• Certification of conformance to NEMA Standard TS-1, Section 2

(22) Testing Requirements

The equipment covered by this specification shall be subjected to design approval tests (DAT), factory demonstration tests (FDT), stand-alone tests, systems tests and 72 hour and 90 day test periods to determine conformance with all the specification requirements. The Engineer may accept certification by an independent testing lab in lieu of the design approval tests to verify that the design approval tests have previously been satisfactorily completed. The VMS vendor shall arrange for and conduct the tests in accordance with the testing requirements stated herein. Unless otherwise specified, the VMS vendor is responsible for satisfying all inspection requirements prior to submission for the Engineer's inspection and acceptance. The contract periods will not be extended for time lost or delays caused by testing prior to final approval of any items. The Engineer reserves the right to have his representative witness any and all tests. 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 the equipment shall be subject to rejection by the Engineer. Rejected equipment may be offered again for a retest, provided that all non-compliance's have been corrected and retest by the VMS vendor and evidence thereof submitted to the Engineer. Final inspection and acceptance of equipment shall be made after installation at the designated location as shown on the plans, unless otherwise specified herein.

(23) Testing Procedures

The VMS vendor shall provide five (5) copies of all design approval, factory demonstration, stand-alone and system test procedures and data forms for the Engineer's approval at least sixty (60) days prior to the day the tests are to begin. The test procedures shall include the sequence in which the tests will be conducted. The test procedures shall have the Engineer's approval prior to submission of equipment for tests.

The VMS vendor shall furnish data forms containing all of the data taken, as well as quantitative results for all tests. The data forms shall be signed by an authorized representative (company official) of the equipment manufacturer. At least one copy of the data forms shall be sent to the Engineer. The VMS vendor shall be responsible for providing the test fixtures and test instruments for all the tests.

(24) Design Approval Tests

Design approval tests shall be conducted by the VMS vendor on one or more samples of equipment of each type, as approved by the Engineer, to determine if the design of the equipment meets the requirements of this Specification. The test shall be conducted in accordance with approved test procedures.

If the design approval tests have not previously been satisfactorily completed by an independent testing lab and accepted by the Engineer, the Engineer shall be notified a minimum of thirty (30) calendar days in advance of the time these tests are to be conducted. The design approval tests shall cover the following:

(a) Temperature and Condensation

The VMS sign system equipment shall successfully perform all the functionality requirements listed in this specification under the following conditions in the order specified below:

- The equipment shall be stabilized at –40°F (–40°C). After stabilization at this temperature, the equipment shall be operated without degradation for two (2) hours.
- Moisture shall be caused to condense on the equipment by allowing it to warm up to room temperature in an atmosphere having relative humidity of at least 40% and the equipment shall be satisfactorily operated for two (2) hours while wet.
- The equipment shall be stabilized at 149°F (65°C). After stabilization, the equipment shall be satisfactorily operated for two (2) hours without degradation or failure.

(b) Primary Power Variation

The equipment shall meet the specified performance requirements when the nominal input voltage is 115 V ±15 V. The equipment shall be operated at the extreme limits for at least 15 minutes during which the operational test of the FDT shall be successfully performed.

(c) Power Service Transients

The equipment shall meet the performance requirements, specified in the parent specification, when subjected to the power service transient specified in Section 2.1.6, “Transient, Power Service”, of the NEMA standard TS1. The equipment shall meet the performance requirements specified in the parent specification.

(d) Relative Humidity

The equipment shall meet its performance requirements when subjected to a temperature of 149°F (65°C) and a relative humidity of 90%. The equipment shall be maintained at the above condition for 48 hours. At the conclusion of the 48 hour soak, the equipment shall meet the requirements of the operational test of the FDT within 30 minutes of beginning the test.

(e) Vibration

The equipment (excluding cabinets) shall show no degradation of mechanical structure, soldered components, or plug-in components and shall operate in accordance with the manufacturer’s equipment specifications after being subjected to the vibration tests as described in Section 2.2.5, “Vibration Test”, of the NEMA standard TS1.

(f) Consequences of Design Approval Test Failure

If the unit fails the design approval test, the design fault shall be corrected and the entire design approval test shall be repeated. All deliverable units shall be modified, without additional costs to the City, to include design changes required to pass the design approval tests.

(25) Factory Demonstration Tests

The VMS vendor shall be responsible for conducting Factory Demonstration Tests on all units at the VMS Vendor’s Manufacturing Facility. These tests shall be performed on each unit supplied. All tests shall be conducted in accordance with approved test procedures. All equipment shall pass the following individual tests:

(a) Examination Tests

Each piece of equipment shall be examined carefully to verify that the materials, design, construction, markings and workmanship comply with the requirements of the Specification.

(b) Continuity Tests

The wiring shall be checked to determine conformance with the requirements of the appropriate paragraphs in the Specifications

(c) Operational Test

Each piece of equipment shall be operated long enough to permit equipment temperature stabilization, and to check and record all performance characteristics to ensure compliance with the

requirements of this Specification. Equipment functionality will be thoroughly tested to verify complete compliance with all areas of this Specification.

(d) Consequences of Demonstration Test Failure

If any unit fails to pass its demonstration test, the unit shall be corrected and another unit substituted in its place and the test successfully repeated. If a unit has been modified as a result of a demonstration test failure, a report shall be prepared and delivered to the Engineer prior to shipment of the unit. The report shall describe the nature of the failure and the corrective action taken. If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the City or extension of the contract period.

(26) Stand-Alone Tests

The VMS vendor shall conduct an approved stand-alone test of the equipment installation at the field site. The test shall, as a minimum, exercise all stand-alone (non-network) functional operations of the field equipment with all of the equipment installed as per the plans, or 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. At least two (2) working days' notice shall be given prior to all tests to permit the Engineer or his representative to observe each test.

(a) Consequences of Stand-Alone Test Failure

If any unit fails to pass its stand-alone test, the unit shall be corrected or another unit 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 the re-testing of the unit. The report shall describe the nature of the failure and the corrective action taken. If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the City or extension of the contract period.

(27) System Test

The VMS vendor shall conduct approved VMS system tests on the field equipment with the central equipment. The tests shall, as a minimum, exercise all remote control functions and display the return status codes from the controller. Approved data forms shall be completed and turned over to the Engineer as the basis for review and for rejection or acceptance.

(a) Consequences of System Test Failure

If system tests fail because of any components(s) in the subsystem, the particular component(s) shall be corrected or substituted with other component(s) and the tests shall be repeated. If a component has been modified as a result of the system test failure, a report shall be prepared and delivered to the Engineer prior to retest.

(28) 72 Hours and 90 Days Test Failure

After the installation of the VMS system is completed and the successful completion of the System Test, the VMS vendor shall conduct one continuous 72-hour full operating test prior to conducting a 90 day test period. The type of test to be conducted shall be approved by the Engineer, and shall consist primarily of exercising all control, monitor and communications functions of the field equipment by the central equipment.

The 90 days test period shall commence on the first day after the successful completion of the approved 72-hour continuous full operating test period. During the 90 days test period, downtime, due to mechanical, electrical and/or other malfunctions, shall not exceed five (5) working days. The Engineer may extend the 90 days test period by a number of days equal to the downtime in excess of five (5) working days. The Engineer will furnish the VMS vendor with a letter of approval stating the first day of the 90 days test period.

(29) Final System Acceptance

Final system acceptance shall be defined as when all work and materials provided for in this item have been furnished and completely installed, and all parts of the work have been approved and accepted by the Engineer and the Variable Message Sign System has been operated continuously and successfully for ninety (90) calendar days with no more than five (5) working days downtime due to mechanical, electrical and/or other malfunctions.

(30) Technical Assistance

The VMS manufacturer's technical representative shall provide on-site technical assistance in following areas:

- Sign housing to ground control cabinet cable termination
- Initial signal turn-on and stand-alone test

The initial powering up of the sign(s) shall not be executed without the permission of the VMS manufacturer's technical representative.

(31) Warranty

Equipment furnished under this Specification shall be guaranteed to perform according to these specifications and to the manufacturer's published specifications. Equipment shall be warranted for a minimum of **one year** parts return to factory against defects and/or failure in design, materials and workmanship. Unless otherwise specified in the invitation for bids, warranty coverage shall become effective on the date of final acceptance of the system by the City. The Contractor shall assign to the City all manufacturer's normal warranties or guarantees, on all such electronic, electrical and mechanical equipment, materials, technical data, and products furnished for and installed on the project. Defective equipment shall be repaired or replaced, at the manufacturer's option, during the warranty period at no cost to the City.

c. Sign Controller

The sign controller shall be a multiple-sourced, non-proprietary, 19-inch rack-mountable, Type 2070 Lite traffic controller meeting the latest CALTRANS Specifications and shall be provided with resident software stored in non-volatile memory. The 2070 Lite shall perform all communication, control and feedback functions and shall be the only sign controller. No intermediate control device shall be used. Proprietary sign controllers shall not be used.

The sign controller shall be programmed to receive sign control commands from the central controller or laptop computer, transmit responses as requested to the central controller or laptop computer, monitor sign and message status and control sign operation and message displays. If applicable, a quick reference card shall be mounted on the front of the controller to reference the major keypad commands and fixed messages.

The controller will have power-up and auto-restart capabilities with a programmable default message (including a blank message) when recovering from a power off condition. A hardware watch dog circuit will be utilized to provide automatic reset to the controller and the modem. The central computer shall be capable of remotely commanding a controller and modem reset. The sign controller shall be capable of being controlled from the central controller or the laptop computer. Communication and control lines between the sign controller and the system interface circuits shall be opto-coupled.

(1) Sign Controller Location

The sign controller shall be mounted inside a Model 334 ground-mounted cabinet at the roadside within 1000 feet of the sign, or as shown in the plans. Communication and control lines between the sign controller and the display system interface circuits shall be opto-coupled.

The following shall be mounted inside the main sign housing:

- Opto-coupled sign interface assembly
- Display system interface circuits
- Local/remote control switch
- Local control LED indicator
- RS-232 plug-in connection for the laptop computer
- RS-232 cable (a minimum of 4 feet long to connect the laptop computer to the sign controller)

The local / remote switch located in the sign shall work in parallel with the local / remote switch located in the sign controller cabinet.

d. Sign Controller Cabinet

The sign controller shall be installed in a cabinet housing that conforms to the CalTrans specification for Model 334 traffic signal controller cabinets and shall be mounted as indicated in the plans. The cabinet shall be constructed using unpainted sheet aluminum with a minimum thickness of 0.125 inch. Material used in the cabinet shall meet NEMA standards. The cabinet shall be completely weatherproofed to prevent the entry of water. All exterior seams for cabinets and doors shall be continuously welded. All exterior welds shall be smooth. The cabinet shall be provided with two full size doors to provide access to both the front and rear of the cabinet. The doors shall be provided with full length stainless steel piano hinges, with stainless steel pins spot welded at the top. The hinges shall be mounted so that it is not possible to remove them from the doors or cabinet without first opening the doors. The cabinet doors shall be fitted with number 2 Corbin locks. Two keys shall be provided for each cabinet. The door opening shall be double flanged on all four sides.

A gasket shall be provided to act as a permanent dust and weather resistant seal at the cabinet door facing. The gasket material shall be closed-cell neoprene and shall maintain its resiliency after exposure to the outdoor environment. The gasket must show no sign of rolling or sagging and must insure a uniform dust and weather resistant seal around the entire door facing. The Contractor shall be responsible for all phone, data, control and confirmation connections between the sign and sign controller cabinet and for any required wiring harnesses and connectors.

A standard EIA 19-inch rack cage shall be installed inside the housing for mounting of the controller unit and cabinet assemblies. The EIA rack portion of the cage shall consist of 2 pairs of continuous, adjustable equipment mounting angles. The angle nominal thickness shall be either 0.1345-inch plated steel or 0.105-inch stainless steel. The angles shall be tapped with 10-32 threads with EIA universal spacing. The angle shall comply with Standard EIA RS-310-B and shall be supported at the top and bottom by either welded or bolted support angles to form a cage. Clearance between rails for mounting assemblies shall be 17.75-inches.

Two steel supporting angles extending from the front to the back rails shall be supplied to support the controller unit. The angles shall be designed to support a minimum of 50 pounds each. The horizontal side of each angle shall be a minimum of 3-inches. The angles shall be vertically adjustable.

The cage shall be bolted to the cabinet at 4 points, via the housing cage supports and associated spacer brackets, 2 at the top and 2 at the bottom of the rails. The cage shall be centered within the cabinet.

The sign controller cabinet shall contain the following assemblies:

- Power distribution assembly containing thermomagnetic circuit breakers for the sign and controller cabinet
- Sign controller
- Modem
- Opto-coupled sign interface assembly
- Cabinet light and switch
- Local/remote control switch and LED indicator
- RS-232 plug-in connection for the laptop computer
- RS-232 null modem cable a minimum of 4 feet long to connect the laptop computer to the sign controller
- For dialup installations, an RJ-11 jack for connecting the dialup phone line shall be installed
- Cabinet fan, thermostat and filtered vent
- GFI duplex utility outlet rated for 15 A, minimum
- A slide-out work tray, for the laptop computer, mounted on ball bearing slides. Cabinet lamps shall be used to illuminate the internal controller cabinet when either of the cabinet doors are opened. The lamps shall be extinguished when the cabinet doors are closed. The lamps shall be positioned and shielded to prevent light from shining in a person's eyes.

e. Sign To Sign Controller Cabinet Interconnection

Cables between the sign and the sign controller cabinet shall be provided for operation of the sign. Signal control and data cables shall be stranded, twisted pair, 300 V, shielded cable. The power cables shall provide 120/240 VAC at 30 A per leg to the sign housing. Power and signal cables shall be in separate conduits. Power and signal cables shall be sized according to load and distance.

f. Sign Controller Modem

Communication between the central controller and the sign controller must be capable of operating with a GDI model SM336SA dial-up modem with a transmission speed of 33.6Kbps. The Contractor shall provide necessary modems at the sign location.

g. Sign Controller Communication Interface

The sign controller shall include separate EIA RS-232D serial interfaces for communication with the laptop computer. Communication from the Sign to the central system shall be Ethernet communication.

The second EIA RS-232D serial port shall be for local communications with the laptop computer. The laptop communication line circuit shall be full duplex asynchronous data transmission at a minimum of 33k bps. The communications between the sign controller and the central controller or laptop computer shall comply with the National Transportation Communications for ITS Protocol (NTCIP). Unless otherwise stated, the software shall comply with the versions of the relevant NTCIP standards that are current at the date of this document.

The sign controller shall support all NTCIP conformance levels, conformance groups, objects, and minimum storage sizes and ranges. In addition to the standard MIB objects, the sign shall include any additional manufacturer-specific MIB objects required to support all of the sign and central software functionality defined elsewhere in this specification.

h. Operating Systems

(1) Central Control Computer(s)

The operating system for the central controller shall be Microsoft Windows NT, Windows 2000, Windows 2003 or Windows XP Professional server operating systems, as directed by the engineer.

i. Laptop Control Computer(s)

The operating system for the laptop or other workstations shall be Microsoft Windows XP operating systems, as directed by the engineer.

j. Service Boxes

Material for junction and service boxes shall be a polymer concrete of select-grade aggregate consisting of sand and gravel bound together with a polymer resin system and reinforced with continuous woven glass strands. It shall have the following minimum properties:

Compressive Strength: 11,000 psi per ASTM C-109/D-3410
Tensile Strength: 1,700 psi per ASTM C-496/D-638/D-2343
Flexural Strength: 7,500 psi per ASTM C-580/D-790

All junction boxes, service boxes, and covers shall be rated at no less than 22,500 lbs. test load (Tier 15) per ANSI/SCTE-77. All boxes shall be stackable for extra depth. The box shall consist of straight sides and open on the bottom. The various types of junction and service boxes shall be sized according to the standard details.

The cover shall have a non-skid textured surface having a minimum coefficient of friction of 0.50 under wet or dry conditions. It shall have a slot with a lift pin for inserting a lift hook. There shall be two stainless steel hex head bolts and washers in opposite corners for bolting down the cover to the box. There shall be a cleanout hole in the box below the bolt to aid cleaning out debris. A logo with the words “Fiber Optic” shall be either embossed or molded into the cover or on a name plate that can be permanently affixed to the recessed area in the box lid.

k. Steel Poles

Steel poles and mast arms shall conform to Section 1608 of the "Standard Specification," the 2013 edition of the American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications for Structural Supports for Signs, Luminaires and Traffic Signals, and the

requirements on the plans. The poles and arms shall be round, tapered monotube made of one length of the best grade, structural steel sheet of not less than #7 Manufacturing Standard Gauge. Only one longitudinal weld, and no transverse welds, shall be permitted in the fabrication of the shaft or arm.

The steel anchor base of adequate strength, shape and size shall be secured to the lower end of the shaft by welding in such manner as to develop the full strength of the adjacent shaft section to resist bending action. The steel poles shall be galvanized to ASTM A-123 standards.

The tapered steel shaft shall include high strength anchor bolts and nuts, conforming to Section 1615 of the "Standard Specifications" and shall be capable of attaching two parallel mast arms as shown on the detail sheets.

All poles shall be detailed on shop drawings by the manufacturer indicating pole and arm dimensions and attachment method along with signal weight, projected areas, and type of mounting that it is designed to accommodate.

The type of pole shall be as specified on the plans. This pole specification is in addition to the pole detail sheet included in the plans. Refer to the pole detail sheet, which describes the pertinent design details.

(1) Steel Pole Material

The steel pole, including anchorage and arms shall be in accordance with the following material requirements:

Component	ASTM Designation	Minimum Yield Strength (ksi)
Tapered Tube	A595 GR. A or A572	55
Pole Base	A572	50
Arm Attachment	A572	50
Arm Connection Bolts	A325	NA
Anchor Bolts	F1554 GR 55	55
Galvanized Hardware	ASTM 123	NA

(2) Pole Dimensions

Pole dimensions shall be as specified in the City of Overland Park Standard Details. It is the responsibility of the fabricator to verify and attest that the material sizes proposed are structurally adequate and in full compliance with this specification and the pole detail sheet. The bolt circle and other pole and arm dimensions are provided in the table as specified in the City of Overland Park Standard Details. The base shall be cast with four slotted holes to receive the anchor bolts and shall have tapped holes for attaching the two arms.

(3) Handhole Opening and Cover

The handhole cover shall attach to the frame centered 18" above the bottom of the shaft. It shall be a minimum of 6 ½" wide and 4 ½" tall and be secured with two ¼" stainless steel hex head screws. The handhole shall be reinforced with a frame. The handhole opening shall be ground smooth and free of all burrs and sharp edges. Handholes shall be located 180 degrees from the plane of the mast arms as viewed from the top.

(4) Ground Lug

Each pole shall contain an internal ground lug welded inside the pole adjacent to the handhole for the purpose of attaching a grounding connector. The ground lug shall have a ½"" diameter tapped hole.

(5) Cable Hook

Each pole shall also contain a ½" diameter hot rolled C-hook cable support welded inside the pole near the top of the pole shaft.

(6) Pole and Arm Caps

Each pole and both arms shall include end caps which shall be fastened to the shaft or arms by means of stainless steel set screws.

(7) Pole Finish

The standard pole shaft shall be provided with a hot dipped galvanized finish.

l. Conduit

Conduit shall be as indicated in the following specification

(1) PVC Conduit Material

Rigid nonmetallic conduit shall be polyvinyl chloride (PVC) conduit manufactured from PVC compounds complying with the UL651 standards (latest version) and sized according to the plans. The conduit shall bear an Underwriters' Laboratories label. It shall also meet NEMA TC2, National Electric Code (NEC) for nonmetallic raceway for wires and cables, and rated for use with 90 degree C conductors or cable. Schedule 40 PVC conduit shall be used underground and schedule 80 PVC conduit shall be used above ground or exposed on the underside of bridge decks.

(2) HDPE Conduit Material

The conduit shall exhibit good workmanship and be free from holes, blisters, inclusions, cracks, and homogenous throughout. There should not be any foreign particles embedded in the plastic as a result of the extrusion process. There should not be any surface distortions that penetrate either internally or externally into the conduit wall greater than 10% of the minimum wall thickness. The conduit shall be constructed of polymeric materials which are lightweight, flexible, corrosion resistant and nonconductive. The base material shall be clean, virgin grade high-density polyethylene (HDPE) which conforms to ASTM D3350, most recent edition, Type III. Any regrind material shall be non-wide specification, reworked from the same virgin material from the same manufacturer as the original conduit. The conduit shall have a controlled outside diameter with the cross-sectional dimensions meeting SDR 13.5 manufactured to ASTM D3035 specifications and having a minimum ASTM cell classification 334480E. The conduit shall be smooth walled inside and out with a minimum coefficient of friction of 0.35. The conduit shall meet the following minimum requirements:

Density	> 0.940 g/cc	ASTM D-1505
Melt Index	< 0.4 gm/10 min.	ASTM D-1238(E)
Flexural Modulus	> 80,000 psi	ASTMD-790
Tensile Strength	> 3,000 psi	ASTM D-638
Slow Crack Growth		
ESCR (Bell Test)	10% Igepal	ASTM D-1693
Test Duration	192 hours min.	ASTM D-1693
Failure	10% max	ASTM D-1693
Molded Plaque	3	ASTM D-1693
Hydrostatic Strength Class	NPR	ASTM D-2837
Color and UV Stabilizer	E > 2%	ASTM D-3350
Ultimate Elongation	>400 %	ASTM D-638

Minimum wall thickness shall be in accordance with the following table:

Diameter	Wall Thickness
1 ½” SDR 13.5	0.141”
2” SDR 13.5	0.176”
3” SDR 13.5	0.259”
4” SDR 13.5	0.333”

Conduit shall be sized according to the plans. The conduit shall be pigmented throughout the entire cross-section so as to produce a uniform black color with three longitudinal white stripes, forming an integral part of the product. All colors shall be produced from light stabilized pigments, which are further protected from ultra-violet (UV) degradation by the incorporation of Hindered Amine Light

Stabilizers (HALS) allowing protection for up to two years of outside storage. The conduit shall be sequentially marked and identified along its outer length in contrasting color and with a print of at least 0.125" height. The print interval shall not exceed five feet and shall include: 1) Manufacturer's name, 2) Product name/number, 3) Production code and 4) Length of Conduit (in feet).

The conduit coming off the reel shall return to a circular shape upon the release of tension when it is unreeled. The conduit ovality as defined in ASTM D-2122 shall not exceed the percentage listed in the following table per ASTM F-2160:

Diameter	% Ovality
1 ½"	7%
2"	7%
3"	10%
4"	15%

When conduit 3" or above in diameter exceeds 10% ovality, it may be used if the contractor uses re-rounding equipment until 10% ovality or less is achieved. The mean elongation defined as the change in length divided by the original length, multiplied by 100 at a given load shall not be more than 10%. The conduit shall recover to a minimum of 95% of its original outer diameter upon release of a 200 pound load or shall not deflect to more than 5% of its original inside diameter within 10 minutes after removal of the compressive load.

m. Conduit Couplings, Elbows and Fittings

Couplings for conduit shall be used to connect two runs of conduit, whether PVC to PVC, PVC to HDPE, HDPE to HDPE, PVC to RGC or HDPE to RGC as appropriate for field conditions and as outlined in the standard details and Approved Equipment List.

(1) PVC Conduit Couplings, Elbows and Fittings

Polyvinyl chloride (PVC) couplings, elbows and fittings shall be schedule 40 or schedule 80 for use with schedule 40 and 80 PVC conduit, respectively and shall be listed to UL-651 (latest revision). Standard PVC to PVC couplings shall have a center stop. Standard and special radius elbows shall either have a plain end or bell end.

(2) HDPE Conduit Fittings

An approved factory coupling or adhesive, as listed in the Overland Park Approved Equipment List shall be used for connection of the HDPE conduit to PVC conduit or between two HDPE conduits.

(a) Conduit Adhesive

The adhesive shall be capable of joining HDPE conduit to PVC, fiberglass and metal conduit using standard PVC couplings. It shall be a rapid cure, two-part resin adhesive supplied in a side-by-side mixing cartridge to form a durable, strong and watertight joint. The adhesive shall have the following minimum properties:

Color	Grey	
Peak Exotherm @ 70º F	< 200º F	
Hardness	70-80	Shore D Durometer
Flexibility	>2%	ASTM D-790
Dielectric Strength	450 Volts/Mil (Nonconductive)	ASTM D-149
Airtight (continuous)	120 psi	
Specific Gravity Part A	1.2	
Specific Gravity Part B	1.2	
VOC	0 g/L	ASTM D-1693
Operating Temperature	-60º F to 250º F	ASTM D-2837

(b) Mechanical Coupling

Couplings shall be able to join HDPE conduit to HDPE or PVC conduit. Couplings can be fabricated from either aluminum or high-density polyethylene and shall be able to mechanically connect to the conduits.

Aluminum body couplings for use on HDPE conduit shall contain a center stop and reverse threads to draw two conduits together and shall be able to be installed by hand. The sharp threads shall be able to withstand high pulling loads that meet or exceed the Bellcore tensile standard of 1,000 lbs. The coupling shall be machined with one degree of taper and have a long chamfered lead-in for straight, easy starting. They shall incorporate a wide, six pitch thread angle which greatly reduces the number of revolutions necessary to install the coupling.

Aluminum body couplings for use between HDPE and PVC conduit shall contain left hand threads on the HDPE end of the coupling that will cause, when installing the female pipe thread, them to tighten further on the conduit. The other end of the conduit shall be machined with regular IPS female pipe threads to accept a male to female PVC pipe adapter while gluing the PVC pipe into the female end of the adapter.

Polyethylene body couplings for use between HDPE conduits or between HDPE and PVC conduits shall have locking rings and external band clamps and 5/16” hex head tightening bolts that are all made from corrosion-resistant stainless steel. They shall be able to be re-entered without any special tools and shall be air and water tight by use of internal o-rings on each end. They shall meet UL-514B standards.

(c) Fusion Couplings

Electrofusion couplings shall be manufactured in accordance with ASTM F-1055 for use with pipe conforming to ASTM D2513/3035, F-714 and with Butt fittings conforming to ASTM D3261 as applicable. They shall be produced from a pre-blended virgin resin that has a PPI listing of PE3408 rating and Hydrostatic Design Basis of 1600 psi @ 73º F. The resin shall have a cell classification of 445574C which complies with ASTM D3350. The heating wire shall be copper, or nickel alloy. The terminal pins shall be machined or die swaged 70/30 brass or nickel-plated carbon steel.

(d) Conduit Expansion Fittings

Conduit expansion fittings shall be two-piece PVC. One piece shall telescope the other to accommodate thermal expansion and contraction along the conduit run. The spigot part of the joint shall slide through an internal o-ring to keep moisture and debris out of the fitting. Couplings for conduits sized through 2” in diameter shall expand up to 4”. Couplings for conduits sized 2” through 6” shall expand up to 8”.

n. Electrical Cable

The contractor shall furnish all wiring both internal to the cabinet and between the cabinet and the DMS components within the housing to provide the required functionality specified herein. Electrical cable shall comply with the following specifications.

(1) Power lead-in cable

Power lead-in cable shall be of the sizes and number of conductors as shown on the plans. The cable shall be for operation on a 600 volt maximum and suitable for use at conductor temperatures not exceeding 75 degrees C. Material, construction, and tests shall be in accordance with the applicable requirements of the I.P.C.E.A. standard S-66-524 "Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy." Conductors shall be stranded, annealed coated copper. Copper wire, before insulating or stranding, shall meet the requirements of the latest edition of A.S.T.M. B-33 (for coated wire). Stranding shall be Class B, in accordance with the latest edition of A.S.T.M. B-8. Insulation shall consist of cross-linked thermosetting polyethylene, meeting the requirements of column B of I.P.C.E.A., and listed by U.L. as type U.S.E. RHW-75 degrees C.

(2) DMS Control Cable

The control cable shall be No. 24 AWG, 4-pair, stranded tinned copper with aluminum/polyester foil plus 90% tinned copper braid. The polyethylene insulation on the individual pairs shall be color

coded. The drain wire shall be stranded, tinned copper equal to the size of the insulated conductors. The outer jacket shall be chrome gray PVC insulation with a nylon rip cord.

(3) Ground Cable

Use an AWG # 6 wire or equivalent bonding straps to bond the sign to the structure. Use an AWG # 6 solid, bare copper wire to bond the sign structure to the ground rod(s). Bond the bottom of the sign structure to one or more ground rods. Use exothermic welding at each end of the ground wire (unless the steel structure has a suitable grounding lug). Use a device that measures resistance to ground using the three-point fall-of-potential method to ensure that the resistance from the sign's ground bar to ground does not exceed 4 ohms. Add more ground rods if necessary to achieve this requirement.

Use an AWG #10 THHN/THWN system ground cable between the ground rod at the DMS structure through the HDPE conduit to the ground buss at the controller cabinet.

o. Service Boxes

Material for service boxes shall be a polymer concrete of select-grade aggregate consisting of sand and gravel bound together with a polymer resin system and reinforced with continuous woven glass strands. It shall have the following minimum properties:

Compressive Strength: 11,000 psi per ASTM C-109/D-3410
Tensile Strength: 1,700 psi per ASTM C-496/D-638/D-2343
Flexural Strength: 7,500 psi per ASTM C-580/D-790

All service boxes, and covers shall be rated at no less than 22,500 lbs. test load (Tier 15) per ANSI/SCTE-77. All boxes shall be stackable for extra depth. The box shall consist of straight sides and open on the bottom. The various types of junction and service boxes shall be sized according to the standard details.

The cover shall have a non-skid textured surface having a minimum coefficient of friction of 0.50 under wet or dry conditions. It shall have a slot with a lift pin for inserting a lift hook. There shall be two stainless steel hex head bolts and washers in opposite corners for bolting down the cover to the box. There shall be a cleanout hole in the box below the bolt to aid cleaning out debris. A logo with the words "Fiber Optic" shall be either embossed or molded into the cover or on a name plate that can be permanently affixed to the recessed area in the box lid.

p. Ground Rods and Clamps

Ground rods located in service boxes shall be 5/8" in diameter x 8' long, fabricated from a rigid, high carbon steel core and tip with a heavy, 99.95% pure, 10 mil minimum uniform coating of copper, metallurgically bonded to the core. They shall be UL-467 rated. The name, length, diameter, part number and UL logo shall be roll-stamped onto the ground rod.

Ground rod clamps shall be fabricated from high strength copper or bronze alloy meeting UL-467 standards with a hex head clamping bolt. It shall be able to accommodate a bare, #10 AWG THHN/THWN copper locating/tracer cable.

q. Meter Service Pedestal and Circuit Breakers

The contractor shall provide circuit breakers as shown on the plans for secondary power drop. The circuit breakers shall be single pole, molded case breakers of the size and trip rating shown on the plans and shall be manufactured by GE or Westinghouse. The circuit breakers shall be provided in a combination meter can/breaker box, rain-tight enclosure provided with a hasp for a padlock to be provided by others.

1062.3 CONSTRUCTION REQUIREMENTS

The dynamic message sign and components shall be installed in accordance with manufacturer's requirements to provide a complete and operational system.

The contractor shall only use qualified laborers who are well trained to perform functions related to the installation of dynamic message signs, including familiarity with applicable sections of the National Electric Code.

a. Excavation

The Contractor shall perform all excavations for installing underground conduits, cable and boxes in whatever substances encountered, to the depths indicated on the drawings or as otherwise approved. During excavation, material suitable for backfilling shall be piled in an orderly manner a sufficient distance from the excavation to avoid slides. All excavated materials not required or unsuitable for backfill shall be removed and wasted at location obtained by the Contractor.

(1) Rock Excavation and Blasting

Where solid rock, shale, or similar material is found, the excavation shall be as shown in the plans or as directed by the Engineer. The areas shall be excavated in accordance with "Rock Excavation and Blasting". ABSOLUTELY NO BLASTING OF ANY KIND WILL BE ALLOWED.

(2) Backfilling

All areas excavated shall be backfilled and compacted. In no instance shall any lift or layer exceed six inches of compacted thickness. Compaction using the bucket of an excavator is not sufficient and shall not be allowed. Small areas shall require compaction with a pneumatic compactor or rabbit's foot tamper. After backfilling, all disturbed areas shall be kept well filled and maintained in a smooth and well-drained condition until permanent repairs are made or surface restoration is completed.

b. Replacing Damaged Improvements

Improvements such as sidewalks, curbs, gutters, Portland Cement concrete and asphaltic concrete pavement, bituminous surfacing base material and any other improvements removed, broken or damaged by the Contractor shall be replaced or reconstructed with the same kind of materials as found on the work or with materials of equal quality. The new work shall be left in a serviceable condition satisfactory to the Engineer. Whenever a part of a square or slab of existing concrete sidewalk, driveway or pavement is broken or damaged, the entire square or slab shall be removed and the concrete reconstructed as above specified.

c. Arterial Dynamic Message Sign

The Contractor shall install the VMS housing on the sign structural supports as shown on the Plans. It is the Contractor's sole responsibility to coordinate the design of the housing and sign structures to ensure compatibility during installation to allow for safe access to the sign housing.

A pre-installation test shall be conducted for each sign to verify that the equipment conforms to the specifications herein, and provides messages that can be viewed by the public. The actual sign controller to be installed in the field with each sign shall be connected to the sign, and all functions as described shall be demonstrated to the satisfaction of the Engineer. The tests shall be conducted in an environmentally controlled Contractor's facilities, in the presence of the Engineer, or his designated representative. The tests for all signs shall be scheduled and conducted within a single 5 day or less consecutive working day (M-F) period. Failure of any portion of the tests shall cause a retest to be scheduled at the Contractor's expense.

A test shall be conducted by an independent testing lab of a random sample of 10 of the pixels for each sign, for conformance to all luminosity and other specifications herein. The testing lab shall be approved by the Engineer.

Prior to installation, a 4-hour burn-in period for all work and equipment shall be performed for each sign supplied under the Contract. The burn-in period shall consist of the field operation of the arterial dynamic message sign system in a manner that is in full accordance with the arterial dynamic message sign system requirements of the Specifications.

d. Sign Controller Installation

The Contractor shall install the sign controller in the cabinet. The Contractor shall make all power connections to the cabinet in accordance with the requirements of these specifications. The neutral bus shall be isolated from the cabinet and equipment ground. It shall terminate at the neutral lug ultimately attached to the meter pedestal.

The Contractor shall make all connections between the AVMS controller and the communications equipment as specified under the specifications for fiber optic communication systems.

e. Dynamic Message Sign Cabinet

The Contractor shall securely fasten the communication cabinet on new concrete bases at the locations as shown on the Plans. Bolted stainless steel connections shall be provided with lockwashers, locking nuts, or other approved means to prevent the connection nuts from backing off. Dissimilar materials shall be isolated from one another by stainless steel fittings.

The Contractor shall make all power connections to the cabinet by means of existing electrical service installed at the nearby traffic signal cabinet, or utility pole as indicated on the plans. All electrical connections shall be performed in accordance with the National Electric Code.

All cable grounding shields and any spare or unused conductors shall be effectively grounded in the cabinet to the equipment grounding terminal strip. The equipment-grounding strip shall be isolated from the cabinet and current carrying neutral. The cabinet current carrying neutral shall terminate at the current carrying neutral ground lug in the meter pedestal or breaker pedestal.

f. Sign Structure and Foundation

Construction shall conform to the applicable sections of the standard specifications and the requirements shown on the plans in accordance with the standard details.

g. Electrical Service Installation

The electrical wiring shall be installed according to the following specifications.

(1) Wiring

Where practical, color codes shall be followed so that the red insulated conductor connects to the red indication terminal, yellow to yellow, and green to green. Circuits shall be properly labeled in all service boxes and at the controller by permanent plastic or aluminum identification tags appropriately attached to the cables by an approved method. Information stamped on the tags shall identify equipment served by the conductor cable in accordance with designations used on the plans.

Install the load center so that the main breakers control all power to the sign and cabinet. Provide at least three branch circuits, one for the sign, one for the controller and communication equipment, and one for the cabinet accessories, such as fan, light, and heater. Only the branch serving the controller and communication equipment shall be protected by the second stage of the surge protector.

Connect the power and control cables in accordance with the manufacturer's recommendations. The 24 AWG, 4-pair control cable shall be installed within a 1" diameter liquid tight flex conduit from the DMS sign housing to the control cabinet.

(2) Bonding and Grounding

All conduit, steel poles and pedestals shall be bonded to form a continuous system, and effectively grounded. Bonding jumpers shall be #6 A.W.G. bare, solid copper wire or equal connected by approved clamps. Grounding of conduit and neutral at service point shall be accomplished as required by the National Electric Safety Code, except bonding jumpers shall be No. 6 A.W.G. or equal. Ground electrodes shall be provided at each signal pole and pedestal and at the controller as detailed on the plans. A #10 AWG THHN/THWN system ground cable shall be connected between the ground rod at the DMS structure and the ground buss at the controller cabinet.

h. Conduit

Conduit installation shall conform to the appropriate articles of the National Electrical Safety Code. The location of conduit runs shown on the plans are for bidding purposes only and may be changed with permission of the Engineer in charge of construction to avoid underground obstructions.

When trenching multiple conduits, a minimum of 12" horizontal or vertical separation shall be maintained between nearest edges of conduits. Any conduit installed in a trench that will be below any paved surface shall be backfilled with AB-3 or crushed rock to a depth of 6" above the top of the conduit and then low strength flowable fill to below the proposed paved surface. When directional boring, only one conduit shall be pulled back at a time. Multiple conduits shall not be pulled through the same bore hole. As much as physically possible, a minimum of 12" horizontal and vertical separation shall be maintained between bored conduits. Boring pits shall be kept 24 inches clear of the edge of any type of pavement wherever possible. Excessive use of water such that pavement might be undermined, or subgrade softened, will not be permitted.

The conduit installed under all roadway surfaces shall be placed a minimum of forty-eight (48) inches below the bottom of pavement elevation to the top of conduit; under drives at a depth of between twenty-four (24) and thirty-six (36) inches below top of pavement; and within park areas at a depth of between twenty-four (24) and thirty-six (36) inches below finished grade. Any conduit installed under existing pavement shall be bored.

Conduit entering equipment shall be continuous into the service box, sign and control center or as otherwise shown on the plans. No couplings or joints will be allowed at intermediate points unless approved by the Engineer in charge of construction.

Conduit bends or sweeps shall have a radius of not less than six (6) times the inside diameter of the conduit. Conduit bends shall be made without crimping or flattening, using the longest radius practicable. The ends of all conduits shall be well reamed to remove burrs and rough edges. Conduit in the bottom of the service box shall extend approximately 3 inches vertically above the aggregate backfill. Conduit shall enter from the direction of the run.

It shall be the privilege of the Contractor at his own expense to use larger size conduit if desired; and where larger size conduit is used, it shall be for the entire length of the run from outlet to outlet. No reducing couplings will be permitted.

Existing underground conduit to be incorporated into a new system or newly installed conduit which will be left empty shall be cleaned with a mandrel and blown out with compressed air. A locating wire shall be placed in any conduit that would otherwise be empty. Expanding foam sealant shall be installed in the end of all conduits in service boxes and at the control center.

The location of all conduits installed or used in this project shall be marked by aluminum markers placed in the top of curb, gutter, or wall, directly above the conduit. The markers shall either be embedded in fresh conduit or they shall be drilled with a recess such that the top of the marker is flush with the finished surface. When markers are installed in a drilled hole, they shall be set with epoxy. The City will provide the markers.

Snaking the conduit under the road will not be permitted. Continuous conduit shall be installed under all pavement crossings between appurtenances. The number of bends in any run of conduit shall not exceed 360 degrees.

It shall be the privilege of the Contractor at their own expense to use larger size conduit if desired; and where larger size conduit is used, it shall be for the entire length of the run from outlet to outlet. No reducing couplings will be permitted.

i. Conduit Couplings

Conduit couplings between appurtenances shall not be allowed unless approved by the Engineer. If approved, fusion couplings or other fusion methods shall be used as specified herein. No matter what coupling is used for the specific application, the end(s) of the conduit shall be round and shall be cut square using an appropriate tube cutters. The contractor shall measure the “stab” depth of the coupler and transfer this measurement on each conduit end with a permanent marker to ensure both conduit ends are fully inserted into the coupling when complete. The coupling shall be centered over the contact points of the two conduits.

(1) Fusion Couplings

Fusion couplings shall require installation by a skilled and certified installer. Proof of certification shall be made prior to installing the coupling. Installation of one test coupling shall be required before this method of coupling HDPE conduit is approved. The certified installer shall be present for every coupling. All heat fusion joining methods require that there is no water flowing or standing in or below the conduit that can reach the fusion surfaces. Conduit surfaces shall be dry prior to and during fusion and should be protected from moisture during rain or snow events. Electrofusion couplings can be installed at ambient temperatures ranging from -10 degrees F to 120 degrees F. Follow the recommendations of the manufacturer. The fusion surface of the coupling shall be clean and free from body oils or other substances that will prevent proper fusing. The ends of the conduit shall be cleaned with 90% or greater concentration of isopropyl alcohol, wiping in only one direction. The area to be cleaned shall be at least two times the full length of the coupling on each end of the conduit. Measure and mark the conduit

slightly longer than ½ the length of the coupling to indicate the scrape/peel length needed. Scribe "witness marks" on the conduit surface. Each end of the conduits shall be scraped or peeled to remove the oxidation and contamination layer with a "peeler" type tool that removes a continuous and measureable ribbon of conduit surface. A minimum of 0.007" of material (thickness of two sheets of paper) shall be removed from each end. None of the "witness marks" shall be visible after scraping. Sandpaper, utility/emory cloth, wood rasps, metal files and abrasives/grinders shall never be used to scrape the conduit ends. Insert the conduit ends into the coupling to the stab depth (½ the length of the coupling). After the conduit has been inserted into the coupling, assembly clamps shall be used to align the ends. The electrical source shall be connected to the electrofusion control box. The contractor shall verify the control box inputs based on the model used. The control box shall acclimate to the jobsite weather conditions for a minimum period of 15 minutes prior to using. The power should be of sufficient output for the size and type of fitting being used. See the power requirements of the manufacturer of the coupling. If an extension cord is used, it should be of sufficient gauge and not more than the specified maximum length according to manufacturer's instructions. Connect the control box leads to the fitting and verify proper fusion time and voltage. Fusion time is different depending on the size of the coupling. After the fusion process is complete, allow proper cooling time while the conduit is still being held by clamps and additional cooling time before rough handling of conduit according to the manufacturer's instructions.

(2) Butt Fusion Plates

Commercial fusion plate machines shall be used in this process. All points on both heating tool surfaces, where the heating tool surfaces will contact the conduit ends, shall be within the prescribed minimum and maximum temperatures. The temperature differentials between any two points on the heating tool fusion surfaces shall not exceed 20 degree F. Clean the inside and outside of the conduit ends by wiping with a clean, dry, lintfree cloth or paper towel. Remove all foreign matter. Align the conduits in the machine by placing them in the clamps and tightening. Conduit ends should protrude past the clamps enough so that facing will be complete. Bring the ends together and check high-low alignment. Adjust the alignment as necessary by tightening the high side down. Place the facing tool between the component ends, and face them to establish smooth, clean, parallel mating surfaces. A complete facing will produce continuous circumferential shavings from both ends. Face until there is minimal distance between the fixed and moveable clamps. Stop the facer before moving the pipe ends away from the facer. Remove the facing tool, and clear all shavings and pipe chips from the component ends. Do not touch the component ends with your hands after facing. Bring the component ends together, check alignment and check for slippage. Look for complete contact all around both ends with no detectable gaps. Verify that the contact surface of the heating tool is maintaining the correct temperature. Place the heating tool between the conduit ends, and move the ends against the heating tool. Bring the conduit ends together under pressure to ensure full contact. The initial contact pressure should be held very briefly and released without breaking contact. Pressure should be reduced when evidence of melt appears on the circumference of the conduit. Hold the ends against the heating tool without force. Beads of melted conduit will form against the heating tool at the component ends. When the proper melt bead size is formed, quickly separate the ends and remove the heating tool. The proper bead size is dependent upon the size of the conduit. During heating, the melt bead will expand out flush to the heating tool surface, or may curl slightly away from the surface. Immediately after the heating tool is removed, quickly inspect the melted ends, which should be flat, smooth and completely melted. If the melt surfaces are acceptable, immediately and in a continuous motion, bring the ends together and apply the correct joining force (or fusion pressure). The correct fusion pressure will form a double bead that is rolled over and contacts the conduit surface. Maintain fusion pressure until the joint is cool to the touch.

(3) Glued Couplings

Install glued couplings within the working temperature as specified by the manufacturer. For conduit over 3" in diameter, taper the end at 45 degrees with a rasp or knife. Abrade and clean both adhesion surfaces and wipe with a clean rag to remove dirt and grime. Sand the outside of the conduit ½" beyond the depth of insertion into the coupling with 80-grit sandpaper as well as the inside of the

coupling. All polish shall be removed. Clean the adhesion surfaces with recommended cleaner. Dispense the adhesive material through the mixing tubes in a 1/8" to ¼" bead using a zigzag pattern the depth of the coupling insert. Squeeze out a small sample prior to applying to the conduit to ensure the product is properly mixed in the mixing tube. The pattern should be about 3/8" in width and extend to the outer edge of the conduit. The coupling shall immediately be twisted onto the conduit and held in place. The joint shall not be moved until the recommended working time is achieved based on the ambient air temperature according to the manufacturer's instructions.

j. Service Boxes

Service boxes shall be installed at the locations shown on the plans. The Contractor may install, at their own expense, such additional boxes as may be desired to facilitate the work upon approval of the Engineer. Service boxes shall be installed on eighteen (18) and eight (8) inches of crushed rock, respectively, as shown on the plans or as directed by the Engineer. Additional rock shall be installed around the base of the box such that the rock extends 2" above the bottom of the box. The excavated opening outside the pull box shall be wide enough to allow compaction of the backfill material. Cinders, broken concrete, broken rock or other hard or undesirable material shall not be used for backfilling. The backfill material shall be placed in layers not to exceed 6 inches deep and each layer shall be thoroughly compacted before the next layer is placed. Boxes shall be installed so that the covers are level with the curb or sidewalk grade or approximately 1 inch above the surrounding earth or sod to match the slope of the existing ground line. Service boxes placed in a paver median or island shall have a concrete border placed around them as indicated in the standard details.

k. Cable

Cable shall be pulled through the installed conduit by use of a polyester/polypropylene pull rope. Caution should be taken as to not burn or tear the conduit ends or conduit body.

Cable shall be carefully pulled through conduit without chafing the insulation jacket on the edge of the conduit. Sufficient slack shall be coiled in the service boxes as indicated on the plans.

l. Post-Installation Testing Requirements

Commence with testing at a given DMS location only after all work required in the Specifications for that ADMS location is completed and all pre-installation testing for all ADMS in the project has been successfully completed. All communications between the given ADMS location and the central control facility shall be established and tested as functional.

1062.4 MEASUREMENT AND PAYMENT

a. Lump Sum

The Engineer will measure the "Arterial Dynamic Message Signs" as indicated on the plans, complete-in-place and accepted, as a unit lump sum quantity for all work necessary.

Payment for "Arterial Dynamic Message Signs" at the contract lump sum price bid is full compensation for the specified work, including furnishing, placing and testing all materials and equipment, and for all tools, labor, equipment, hardware, operational software package(s), supplies, support, personnel training, shop drawings, documentation and incidentals necessary to complete the work.