

# Special Specification 6434

## Embedded LED Dynamic Message Sign System



### 1. DESCRIPTION

Furnish and install full matrix embedded Light Emitting Diode (LED) Dynamic Message Sign (DMS) with nominal 18 in. tall characters. With each DMS, Furnish and install equipment cabinet with DMS controller at the base of the sign's support structure. Provide manufacturer approved end user training.

In the case of conflicts between standards and specifications, the latest State of Texas and Department standards and specifications will govern.

### 2. MATERIALS

2.1. **General Requirements.** All materials furnished, assembled, fabricated, or installed under this Item must be new, corrosion resistant and in strict accordance with this item and the pertinent requirements of the following:

- NEMA TS 4, latest edition,
- Department Special Specification 6008 "Intelligent Transportation System (ITS) Ground Mounted Cabinet,"
- Department Special Specification 6064 "Intelligent Transportation System (ITS) Pole with Cabinet," applicable to cabinet only,
- Department Special Specification 6028 "Dynamic Message Sign System" for installation, and
- vendor must be ISO 9001 registered.

Furnish at least eight licensed copies of vendor software on Department laptops for each Embedded LED DMS, ensuring at least one CD, DVD, or electronic copy is delivered, should the licensed copy need to be reinstalled. Any auxiliary software needed for execution or diagnostics, must be supplied by the vendor.

Ensure that all materials and construction methods necessary to complete the installation conform to the requirements of the Item, the plans, and the pertinent requirements of the following items:

- Item 432, "Riprap"
- Item 441, "Steel Structures"
- Item 445, "Galvanizing"
- Item 449, "Anchor Bolts"
- Item 618, "Conduit"
- Item 620, "Electrical Conductors"
- Item 636, "Signs"
- Item 656, "Foundations for Traffic Control Devices."

Furnish the following equipment at each Embedded LED DMS field site as shown on the plans or as directed:

- low profile multiple LED inserts to mount easily and securely to integrate with static signs,
- sign controller with software, NTCIP compliant, embedded LED DMS mounting brackets and hardware,
- cabling and connectors from power source to embedded DMS connection point as specified by the Embedded LED DMS manufacturer,
- cabling and connectors from telecommunications source to DMS connection point as specified by the Embedded LED DMS manufacturer when required,

- power and communication cabling and connectors from controller to DMS must follow NEMA TS4, Section 4, "Controller to Sign Interface,"
- communications as shown on the plans or as directed,
- pole-mounted control box,
- DMS cabinet (pole or ground mount) and electronics as shown on the plans or as directed, and
- documentation.

2.2. **Embedded LED Dynamic Message Sign.** Ensure the embedded full matrix LED DMS meets the following requirements:

The embedded LED DMS must enable the display of text, consisting of a string of alphanumeric and other characters. Each character must be formed by a matrix of luminous pixels. All display elements and modules must be solid state. No mechanical or electromechanical elements or shutters must be used. The configuration details of signs described by this Specification can be seen in Table 1 below.

**Table 1**  
**Embedded LED DMS**

Sign Access Type	Front Access
Display Type	Monochrome Amber LED
LED Matrix Type	Full or Line Matrix
Pixel Layout	
Display Matrix (H x W)	7 in. x 15 in.
Display Module (H x W)	7 in. x 5 in.
LED Type, Color, Wavelength	AlInGaP / Amber / 590 nm
LED Viewing Angle	30°
Brightness	9,200 cd/ m <sup>2</sup>
Maximum Pixel pitch	2.75 in. (70mm)
Pixel Diameter	1.50 in.
Default Display Background Color	Black
Default Display Numeral Color	Amber
DMS Width	4 ft. (Nominal)
DMS Height	2 ft. 2 in. (Nominal)
DMS Depth (w/o mounting)	6.13 in. (Nominal)
Approximate DMS Weight (without any brackets or mounting hardware)	50 lb.
Sign Controller Location	ITS Cabinet as specified on the plans

2.2.1. **Physical Characteristics.**

2.2.1.1. **General Construction.** Equipment design and construction must use the latest available techniques with a minimum number of different parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality. The equipment must be designed for ease of maintenance. All component parts must be readily accessible for inspection and maintenance. Test points must be provided for checking essential voltages.

Securely clamp cables in sign housings with cable attachments. Do not use adhesive attachments.

Ensure performance of the signs are not impaired due to continuous vibration caused by wind, traffic, or other factors. This includes the visibility and legibility of the display.

Ensure the presence of power transients or electromagnetic fields, including those created by any components of the system, will have no deleterious effect on the performance of the system. Ensure the system does not conductor 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.

#### 2.2.1.2. **Housing.**

The sign housing skin must be constructed of aluminum alloy 5052-H32 which must not be less than 1/8 in. thick, unless otherwise specified in this document. Framing structural members must be made of aluminum alloy 6061-T6.

The equipment within the sign housing must be protected from moisture, dust, dirt, and corrosion. The lift-face housing must meet NEMA 3R enclosure criteria as defined in NEMA Standards Publication 250-2008, "Enclosures for Electrical Equipment (1000 Volts Maximum)."

The sign housings are designed in accordance with "AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals – 6th Edition; for wind speeds of up to 140 mph." AASHTO group load combinations include total sign weight dead load, ice, and wind loads; and the design meets the fatigue requirements for truck-induced gusts.

The housing face must be a two-piece construction, consisting of internal structural members and display modules. The border from the display area to the edges of the sign must be a minimum of 4 in.

There will be no exposed fasteners or welds on the housing face.

The bottom panel of the housing must 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 will be replaceable.

The housing must be designed to accommodate mounting on the rear vertical plane.

#### 2.2.1.3. **Surface Finish.** The face (lens panel aluminum mask) must be finished with a matte-black, licensed-factory-applied, KYNAR 500 Resin, fluropolymer-based coating system. The face must be uniform in appearance and completely free from distortion, gouges and any other flaws or defects. A certification must be required from the licensed-factory KYNAR 500 coater for all aluminum face materials.

All other exterior surfaces will be a natural aluminum mill finish. No painted surfaces will be allowed.

#### 2.2.1.4. **Exterior Skin.** The exterior skin of the housing will be 5052-H32 aluminum alloy sheet with 0.125 in. minimum thickness.

The number of seams must be kept to a minimum. All exterior seams and joints must be sealed to form a rain and weather tight enclosure.

The skin material must be stitch welded to the internal structural members or a formed cabinet to form a unitized structure.

#### 2.2.1.5. **Lens Panel Assembly.** The Lens Panel Assembly must consist of a KYNAR 500 coated aluminum mask over a clear glazing. The aluminum mask must be laminated and sealed to the surface of the glazing using the 3M Scotch VHB joining system or pre-approved equivalent.

#### 2.2.1.6. **Lens Panel Aluminum Mask.** The Lens Panel Aluminum Mask must be:

- 0.063 in. minimum thickness,
- finished with a matte-black, licensed-factory-applied, KYNAR 500 Resin, fluropolymer-based coating system, and

- perforated to provide an aperture for each pixel on the display modules. Each aperture should be as small as possible, without blocking the LED light output at the required viewing angle.

2.2.1.7. **Sign Display.** The face panel clear glazing (if used) must be 90% UV opaque, non-breakable, polycarbonate, or equivalent, minimum 1/8 in. thick, and clear in color and meets AASHTO requirements. Laminate and seal the glazing to the inside surface of the lens panel.

The sign face must not be subject to fogging, frost, and condensation. If an automatically controlled system is used to keep the front face panel free of fog, frost, and condensation, provide ability for monitoring and control by the sign controller. Heat generated by the system must not damage any part of the Embedded LED DMS.

2.2.2. **Environmental Control.**

2.2.2.1. **Temperature and Humidity.** Provide signs and associated field electronics that satisfy at a minimum Section 2.1.5 "Temperature and Humidity" of the NEMA TS 4, latest revision.

2.3. **Optical and Electrical Requirements.**

2.3.1. **LED and Pixel Characteristics.** The LEDs must be rated for 100,000 hr. continuous operation at 30 milliampere drive current, with less than 30% lumen depreciation. The cone perimeter will be defined by its 50% intensity points. The LEDs must have standoffs that hold the base of the LEDs 3.5 mm + 1.0 mm off the printed circuit board to promote cooling of the LEDs. Through-hole LEDs mounted flush to the printed circuit board are not acceptable. Surface-mount LEDs are not acceptable. The brightness of each LED will be measured in accordance with the CIE Test Method A, as described in CIE 127-1997, "Technical Report: Measurement of LEDs." The LED brightness and color bins that are used in each pixel will be provided to the engineer for approval. Certification must be provided, with the submittals, from the LED manufacturer that demonstrates that the LEDs were tested and binned in accordance with the CIE Test Method A.

The LEDs in each pixel must be clustered to maximize long range visibility. All pixels will have equal color and on-axis intensity. All pixels in all signs in this project, including the spare parts, will have equal color and on-axis intensity. The method used to provide the equal color and intensity, as stated above, must be included in the submittals, and approved by the Engineer.

The pixel strings must be powered from a regulated DC power source and the LED current must 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 must not affect the operation of any other string or pixel. Pixel power drawn from the DC supplies must not exceed 1.5 W per pixel, including the driving circuitry.

The LEDs must be individually mounted directly to a printed circuit board and must be easily replaceable and individually removable using conventional electronics repair methods.

2.3.2. **Display Module and Driver Boards.** Each display module consists of a display board with a matrix of LED pixels. The pixels are mounted on the front side of the display module.

Each driver board must have the capability to control a minimum of 9 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 must receive control signals and display data from the sign controller. The display module must contain the control and memory elements and provide the signals to switch and read the LED pixels.

The driver boards must connect to a single control cable common to each line of display modules.

The LED display board must contain all LEDs required to form a matrix of pixels. Pixels must be arranged uniformly to display a dot-matrix character of the desired height and width. The height of a standard

character will 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. Smaller characters are not acceptable.

The display modules must be rectangular and 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 must 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 must be equal to the horizontal distance between the rows of a single display module.

All LEDs must be individually and directly mounted to the LED circuit board to form the LED display board. The LED circuit board must be a single, 0.062 in., FR4, flat black printed circuit board. The LED display board must support the driver board.

All LEDs must be mounted so that their mechanical axis is normal  $\pm 1.00^\circ$  to the face of the sign to ensure brightness uniformity over the face of the sign.

Design modules such that failure of one or more pixels, does not affect the operation of other pixels. Ensure failure of any module does not affect the operation of other modules.

Conformal coat Printed Circuit Boards (PCB) with a minimum 0.005 in. (5 mil) thick silicone resin or acrylic resin conformal coat. Use coating material that complies with military specification MIL-I-46058C Type SR and IPC-CC-830.

The option of with driver circuitry into the module is also considered acceptable.

- 2.3.3. **Display Assembly.** Each display module must include an LED display circuit board. A single data exchange and addressing cable must connect the driver board to the LED boards it controls that are not directly attached to the driver board. The driver board must contain the solid-state electronics necessary to control pixel data and read pixel status.

All LED boards and driver boards must be fully interchangeable and must not require any manual addressing switches or adjustment when interchanged or placed in service.

The display modules must be mounted to the display face in a manner that facilitates easy and rapid removal of each display module without disturbing adjacent display modules. Replacement of a complete display module must be possible without the use of any tools.

- 2.3.4. **Legibility.** The characters must be legible under all light conditions at 350 ft. within the degree cone of vision centered around the optical axis of the pixel. The cone perimeter will be defined by its 50% intensity points.

The sign must be the proper brightness in all lighting conditions for optimum legibility. It must 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 must be uniform over the entire face of the sign within the cone of vision from 350 ft. to 50 ft. in all lighting conditions. Non-uniformity of brightness or color over the face of the sign under these conditions will be cause for rejection of the sign.

The sign and its controller must meet a minimum Section 8.8 "Brightness Controls" of the NEMA TS 4, latest revision. The controller must monitor and self-adjust the brightness of the display. Ensure brightness is manually and automatically adjustable from the local sign controller. Enable brightness control to be set to specific levels from the sign controller (local), laptop (remote) and Lonestar™ (central) software.

- 2.3.5. **Characters Displayed.** The signs must 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 must be substituted for any of these characters.

The sign must be able to display compressed (4 in. x 7 in.) or change the default spacing between characters. The spacing options must be 1, 2, or 3-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.

The sign must have the capability to display automatically scaled character fonts applied to a given message to maximize the font size of the displayed text, up to the full height of the display for a single line of text. The sign size must be 7 in. x 15 in. sign matrix.

- 2.3.6. **LED DC Power.** The voltage to the LED modules and associated electronics must 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 must not exceed 1.0%. The power supplies must have an efficiency of 75%.

The power supplies must be paralleled in a diode or configuration and supply enough power to run 100% of all pixels at 100% duty cycle at 65°C (149° F). Functioning supplies must current-share to within 10%.

There must 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 must not vary more than 50 millivolts over all the display modules in the sign with 17 pixels on at 100% intensity in every display module.

- 2.3.7. **Photoelectric Sensor Devices.** These devices must permit automatic light intensity measurement of light conditions at each sign location. These photocells must be mounted in a manner to measure front and ambient light conditions.

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

Pixel brightness must be controlled by pulse width modulation of the DC current. The pixel current waveform must have a frequency of 100 +/- 5 Hz at nighttime brightness levels and greater than 2400 Hz at daytime brightness levels with an adjustable duty cycle of 0.1% to 99.9% in 0.5% or finer increments.

There must 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 shining on the sign. The adjustment must be made from the central controller or laptop computer and must 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 must 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.

- 2.3.8. **Power.** The sign and its sign controller must operate with 120/240 VAC plus or minus 8%, 20 A per leg, 60 Hz, single-phase power.

Inside the sign housing, all 120 VAC service lines must be independently protected by a thermomagnetic circuit breaker at the sign housing entry point. All 120 VAC wiring must be in conduit, pull boxes, raceways or control cabinets as required by the latest version of the National Electric Code (NEC). No 120 VAC wiring must be exposed to the inside or outside of the sign housing. The sign housing must 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, must have no deleterious effect on the performance of the system. The system must 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 must have a 20 A two-pole (common trip) main, 120/240 VAC, single phase, four wire load center with 20 circuit capability. Each circuit in the sign must be powered from a separate circuit breaker.

The system power and communication lines must be protected by transient voltage suppression devices including MOVs and spark gap arrestor.

The efficiency of the power supply must be 80% or greater when operated at 50% to 100% of maximum load. The power supply must have a power factor of 0.95 or greater at operating voltage from 50% to 100% of maximum load.

A minimum of two power supplies must be provided for redundancy. Power supplies must be designed such that if one supply fails, the remaining supply must be able to operate 100% of the pixels at full brightness. Supply 50%, 80%, and 100% full-load calculations for Volt-Amps-Reactive (VARs) and Volt-Amps (VA) loads consumed by Embedded LED DMS sign, operating at 240 VAC.

The sign controller must monitor and report to Lonestar™ the output voltage and functional status of regulated Direct-Current (DC) power supplies located in the Embedded LED DMS by monitoring diagnostic outputs located on these power supplies.

Ensure GFCI devices protect all service outlets, both at the sign display and in the cabinet. At a minimum, there must be one duplex outlet at the display, and one duplex outlet inside the cabinet.

Ensure AC cables are type Cross-Linked High Heat Water (XHHW) and sized as required by the NEC.

Ensure flashing beacons are on an isolated circuit breaker capable of being turned off without affecting the sign function.

- 2.3.9. **Transient Test Requirements.** The sign housing electronics and the control cabinet must be separately capable of withstanding a high-energy transient with the following characteristics repeatedly applied to the AC input terminals:
- a 10 microfarad oil filled capacitor charged to 1000 VDC  $\pm$ 5% must be discharged into the power input terminals a minimum of three times for each polarity, and
  - immediately following this test, the unit under test must perform all its defined functions upon the restoration of normal AC power.

- 2.4. **Field Equipment Cabinet.** With each embedded LED DMS, furnish one ground mount or pole mount cabinet configurations as specified in the plans. Furnish cabinet meeting minimum materials and construction requirements of Special Specifications Item 6008, "Intelligent Transportation Systems (ITS) Ground Mounted Cabinet" and Special Specifications Item 6064, "Intelligent Transportation System (ITS) Pole with Cabinet" (applicable to cabinet only) with additional features described herein.

Provide the following items in the field equipment cabinet

- power-on indicator,
- room for communication devices (shelf mounted and rack-mounted switches, modems, terminal servers),
- local/remote switch and LED indicator,
- alarm switch when the cabinet has been opened and capable of communicating with Lonestar™,
- provide a full-height standard EIA 19-inch rack. The rack must be secured within the cabinet by mounts at the top and bottom,

- provide a minimum of one empty pull out drawer. Ensure drawer can support a 20-lb. load,
- provide outdoor rated markings and identification on the power protection panel,
- provide cabinets with minimum 0.090" thick aluminum, 5052-H32, mill finish sun shields on top, front, and both sides offset from cabinet shell, and
- provide cabinets that are painted white on the interior and left with steel finish on the exterior.

- 2.4.1. **Sign Controller.** Provide a sign controller with resident software. Ensure controller has a what-you-see-is-what-you-get (WYSIWYG) LCD display, representing the message being displayed. Perform all communication, control, and feedback functions for the Embedded LED DMS through the local sign controller. Ensure sign controller supports all Lonestar™ software functionality. Include a front panel user interface with graphical LCD “and” or “or” keypad for direct operation and diagnostics as described (keypad not needed for touchscreen interface).

Send and receive messages from the sign controller through the communication demarcation point in cabinet via the communications porthoused in the field equipment cabinet. Furnishing and installation of communications and power cables from the cabinet to the utility service or the communications demark is described in Special Specifications Item 6028, “Dynamic Message Sign System.”

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 used to provide automatic reset to the controller and the modem. The central computer must be capable of remotely commanding a controller and modem reset.

The sign controller must be capable of being controlled from the central controller or the laptop computer.

- 2.4.2. **Modes of Operation.** Ensure the modes of operation are consistent with those defined in NTCIP, specifically local, central, and central override.

Ensure the sign controller can monitor individual sensors status. Controller must be able to pass sensor information to Lonestar™ such as Power Status Data, Temperature Sensor Data, and Light Sensor Data as defined in NTCIP 1203. The controller must have cabinet door-open sensor and report back door-open status to Lonestar™.

If a communications failure with the Embedded LED DMS central control software, the local sign controller sets the sign to blank, all pixels off, after a user-defined number of minutes unless communications are restored within this period.

The local sign controller must be remotely resettable from the central control software.

During any time, the controller is in reset or bootup condition the message must be in neutral state (default, blank, all pixels off).

Embedded LED DMS sign controller must support the storage and use of a minimum of 255 Texas Manual on Uniform Traffic Control Devices (TMUTCD) graphics which can be formatted and displayed.

## 2.5. **Communication**

- 2.5.1. **Ports for Remote Communication.** Controller must provide a minimum of one Ethernet port with RJ45 connector and a minimum of one EIA232 (RS232) configurable to EIA485 (RS485) with DB9 connector.

- 2.5.2. **Ports for Local Communication.** Controller must provide a minimum of one Ethernet port with RJ45 connector, a minimum of one EIA232 (RS232) configurable to EIA (RS485) with DB9 connector.

- 2.5.3. **Protocols.** The communications ports for the sign will act in accordance with all commands defined in Section 8-10-7 “NTCIP Protocol and Command Sets” of the NEMA TS 4, latest version. Ensure the communications ports for the sign act in accordance with all Department NTCIP user defined commands.

- 2.5.4 **Communication Interface.** The sign controller must include separate serial interfaces for communication with the central controller and the laptop computer.

The communications between the sign controller and the central controller or laptop computer must comply with the National Transportation Communications for ITS Protocol (NTCIP). Unless otherwise stated, the software must comply with the versions of the relevant NTCIP standards that are current at the date of this document.

In addition to the standard MIB objects, the sign must include any additional manufacturer specific MIB objects required to support all the sign and central software functionality defined elsewhere in this specification.

## 2.6. **Clock and Timer**

- 2.6.1. **Internal Clock.** The controller must meet at a minimum Section 8.9.4 "Internal Clock" of the NEMA TS 4, latest version. Internal Clock will be backed up with a non-battery device such as a large capacitor (super capacitor) for a minimum of 168 hr.

- 2.6.2. **Watchdog Timer.** The controller must meet at a minimum Section 8.9.5 "Watchdog Timer" of the NEMA TS 4, latest version. During watchdog timer reset the sign will be blank, all pixels off.

When polled by Lonestar™ the local sign controller will submit a status report to the central control software when a watchdog event has occurred, including the current sign status and must wait in a neutral state until further instructions are sent from the statewide central control software, or until manually reset by local control.

- 2.7. **Initial Documentation.** Before sign manufacturing, provide Embedded LED DMS manufacturer's documentation for each sign type. Document must include each applicable equipment item or component in a searchable PDF manual and submit it for approval. Provide electronic copies of the manual and a minimum of one paper copy of the manual for each sign delivered. Ensure that Embedded LED DMS manufacturer's manual includes:

- independent laboratory test reports explaining testing process and verification worksheet displaying NEMA TS 4 compliance,
- Department will verify, through use of the Department's NTCIP Tester, that the equipment complies with the requirements of "NTCIP 1101 Simple Transportation Management Framework; NTCIP 2101, Subnet Profile for PMPP",
- vendor must submit documentation of successful software compliance testing with Department's Lonestar™ Embedded LED DMS subsystem, latest version,
- maintenance software must be provided by the vendor to the Department at no cost to the Department and this software must allow fonts to be added or changed by the Department,
- documented testing procedures (see section 3.4),
- embedded LED DMS shop drawings,
- power load requirements (for Sign and for the Controller Cabinet) and communications cabling pinouts for cables run between the Cabinet and Embedded LED DMS sign (as per Special Specifications Item 6028, "Dynamic Message Sign System"),
- complete and accurate schematic diagrams including circuit board schematics,
- complete and accurate cabinet, enclosure, and building wiring diagrams,
- complete installation procedures,
- complete performance specifications (functional, electrical, mechanical, and environmental) on the unit,
- complete parts list including names of vendors for parts not identified by universal part numbers such as JEDEC, RETMA, or EIA,
- pictorial of component layout on circuit board,
- complete stage-by-stage explanation of circuit theory and operation,

- complete and detailed system operations manuals,
- data necessary for isolation and repair of failures or malfunctions, assuming the maintenance technicians to be capable of analytical reasoning using the information provided in above subsection describing accuracy, limits, and tolerances for all electrical, physical, or other applicable measurements,
- include general instructions for disassembly, overhaul, and reassemble, including shop specifications or performance requirements,
- detailed instructions where failure to follow special procedures would result in damage to the equipment, improper operation, or danger to operating or maintenance personnel,
- such instructions and specifications must be included only for such maintenance as may be accomplished by specialized technicians and engineers in a modern Electromechanical shop,
- describe special test setup, component fabrication, and the use of special tools, jigs, and test equipment,
- detailed physical description of size, weight, special mounting requirements, electrical connections, power requirements, and all other pertinent information necessary for proper installation and use of the equipment,
- ensure the vendor works with Contractor to submit sign supports and support brackets, and shop drawings compliant with Special Specifications Item 6028, "Dynamic Message Sign System",
- periodic maintenance schedule, and
- list of certified maintenance personnel, including qualifications, experience, and applicable certifications, of individuals who may be performing maintenance on products as required by this specification.

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### 3. CONSTRUCTION

- 3.1. **General.** Install Contractor-furnished Embedded LED DMS according to the manufacturer's recommendations and in accordance with Section 3 Construction of SS6028 "Dynamic Message Sign System". Ensure installation and configuration of software on Department computers is included with the Embedded LED DMS.
- 3.2. **Requirements for Shop Drawings.** Submit shop drawings in Microstation DGN and PDF format for approval before fabrication; include the sign structural members and attachment supports in accordance with Standard Specification Item 5 Article 5.2 "Plans and Working Drawings". Shop drawings must be sealed by a registered professional engineer (licensed in the U.S.).
- 3.3. **Delivery.** Deliver sign and cabinet to location determined by the Department, including removing sign from delivery truck onto ground. The Department will not provide any crane equipment to lift sign off truck. Must provide equipment to lift. The Department will not be held liable for any damages incurred during shipment, including lifting the sign from delivery truck onto ground. Delivery will not be complete until sign has been unloaded onto ground, secured to prevent tipping, and passed the demonstration test.
- 3.3.1. **Final Documentation.** Provide as-built final documentation for approval reflecting all field changes and software modifications. Include detailed drawings of conduit layouts, cable diagrams, wiring lists, cabinet layouts, wiring diagrams and schematics for all elements of the communications system. Include the cable type, color code and function, the routing of all conductors' pairs in the cable diagrams and wiring lists.
- Provide manufacturer's software, documentation, and intellectual property rights for the computer software system and components. These must include, but are not limited to, the following:
- deliver one copy of all documentation supplied by the manufacturers for all plug-in circuit cards used in the microcomputer chassis,
  - grant the Department a non-exclusive unrestricted license that will allow the Department to use, modify, or distribute any or all the stated communication protocols and documentation, and
  - technical assistance to include instructions for troubleshooting and warranty replacements.

- 3.4. **Testing.** Ensure that the Department receives a sign capable of complying with the following test procedures which must be performed upon delivery of the Embedded LED DMS to the Contractor's yard and again at installation of the Embedded LED DMS on the support structure as located in the plans:
- Contractor must examine each unit carefully to verify that the materials, design, construction, markings, and workmanship comply with the requirements of the parent Specification,
  - Department may also verify that the Embedded LED DMS furnished by the Contractor meets Specification,
  - Department may check the wiring to determine conformance with the requirements, and
  - Contractor must operate each unit for 2 hr. to permit equipment temperature stabilization and an adequate number of performance characteristics to ensure compliance with the requirements.
- 3.4.1. **Pixel Status Tests.** Contractor must conduct pixel status tests to ensure the pixels are fully functional. Ensure that Vendor must provide detection for out-of-service LED pixels through testing procedures conducted through the sign controller. When polled, controller must be required to report results to Lonestar™ Embedded LED DMS central software. The following test must be conducted:
- pixel test in which the sign must be capable of a full operational status of each pixel and report the status to the local sign controller.
  - upon request from Lonestar™ software, sign must identify a list of modules with defective pixels,
  - pixel test may briefly disturb the displayed message for no more than 0.5 sec,
  - upon request from Lonestar™ software, sign must provide a list of which pixels are on/off, and
  - pixel read must not interfere the displayed message.
- 3.4.2. **DMS Testing Procedures.** Contractor must coordinate with the vendor to be present during all testing. Contractor must submit manufacturer-approved test procedures and worksheets detailing the following tests to ensure Embedded LED DMS meets all specifications as defined:
- initial demonstration, and
  - stand-alone.
- Contractor must ensure that vendor representative must perform both tests at location determined by the Department
- 3.5. **Maintenance.** Ensure that the installed Embedded LED DMS has a manufacturer's maintenance plan. Vendor must perform periodic maintenance during the warranty period as follows:
- vendor must submit a recommended periodic maintenance schedule for the review by the Department,
  - vendor must have a maintenance representative located within the State of Texas. Visits by the representative to various locations identified by the Department will be required. Representative will be notified by telephone at the location and telephone number designated by the vendor as the point of contact for any repair work. Vendor must notify the Department immediately of any changes in this location and telephone number. Maintenance representative must possess and maintain an inventory of common replacement parts,
  - vendor must perform periodic maintenance tests four times per year during the warranty period at no additional cost to the Department. This periodic maintenance may be performed remotely. Provide documentation to Department,
  - vendor must perform periodic Embedded LED DMS equipment maintenance on-site at intervals not exceeding 12 mo. The vendor must be responsible for all costs related to this requirement, including but not limited to the following: travel, per diem, labor, material, equipment, on-site labor, on-site material, on-site equipment, and access to the signs. The vendor must satisfy TMUTCD for temporary traffic control requirements and shall obtain approval from the Department,
  - vendor must provide to the Department a quarterly report of activities performed, in an electronic spreadsheet format. This report must include all activities performed, equipment serviced, dates, and names of technicians who performed the maintenance. The report must include both periodic

maintenance activities as well as warranty repair work, independently categorized. Include a list of all trouble calls, with time and date received, and time and date responded, including technician, and

- minor items such as pixel outages which do not significantly affect sign operation can be scheduled for future repair not subject to the 72-hr. requirement

- 3.6. **Training.** Provide manufacturer approved end user training to the Department and their representatives. Provide a minimum of 16 hr. of instruction in the operation and maintenance procedures. Train a maximum of ten Department designated personnel. The training will need to include both classroom and field settings. The training location will be determined and provided by the Department.

Training will cover at minimum but is not limited to:

- hands-on operation of the sign,
- explanation of any system commands, their function and usage,
- required preventative maintenance procedures,
- equipment servicing procedures,
- sign troubleshooting and problem identification procedures, and
- use of diagnostic software.

Furnish a manufacturer approved training session agenda, a complete set of manufacturers approved training materials. Provide one copy of the course material for each person. The training room will be provided by the Department.

- 3.7. **Warranty.** Ensure that the installed Embedded LED DMS has a manufacturer's warranty covering: Materials must be warranted for 5 yr. from accepted installation date. The accepted installation date is defined as the date the Department determines the sign has passed installed testing requirements. The warranty must cover all defects in material, design, and workmanship, and must cover 100% parts and labor for repair work, including diagnostics. If the vendor standard warranty period exceeds 72 mo., with a minimum of 60 mo. from accepted installation date, then the standard warranty period shall be in effect. The vendor must submit in writing the terms of warranty.

During the warranty period the vendor will be responsible for labor, materials, shipping, traffic control and other costs as outlined below for required warranty repair. It is the intent of this warranty that the vendor performs warranty repair work. At the Department's option, the Department may perform minor warranty repairs at the vendor's expense without voiding the warranty.

All diagnostics, testing, and replacements necessary to resolve any problems must be assumed by the vendor at no cost to the Department.

- 3.7.1. **Repairs.** The maintenance representative must respond within next business day and be available for warranty repairs and performance of services within 72 hr. of notification by the Department throughout the duration of the Warranty. Failure to meet this requirement may result in the Department billing the vendor for repair work performed by the Department or through a 3rd party without voiding the Warranty. Document all repairs within the quarterly report of activities.

- 3.7.2. **Exclusions.** The Department will assume the expense for replacement of knocked down cabinets, support structures, and other minor items resulting from day-to-day operations. The Department will assume responsibility for cost of repairs resulting from collision, theft, vandalism, or acts of God.

If vendor arrives at location for diagnostics or repair and Department subsequently determines an exclusion, then Department will assume responsibility for vendor's time and travel costs.

- 3.7.3. **Warranty Repairs by the Department.** The vendor performs all warranty repairs; however, at the Department's option, warranty repairs deemed by the Department to be minor in nature or due to vendor's failure to respond within 72 hr. of notification may be performed by the Department at the vendor's expense. Parts required for repairs made by the Department will be obtained from the vendor at no cost to the

Department. The Department may request reimbursement for additional time incurred such as technician's travel time or diagnostic time. Reimbursement by the vendor to the Department for the cost of warranty repairs must be computed as follows:

- labor for warranty repairs will be calculated including travel to field locations, configuring devices, and running diagnostics on field device and communications equipment,
- warranty repairs will be accumulated on Department repair orders and will be billed from same, unless the vendor prefers to have claims processed on the vendor's standard forms,
- replaced parts will be held 30 calendar days and will be available for inspection by the vendor or authorized representative,
- copies of invoices for all parts will be provided to the vendor,
- cost of parts other than those furnished to the Department at no cost by the vendor will be billed at actual cost,
- costs for minor warranty repairs will be accumulated, including labor, diagnosis time, and replacement parts (if not provided),
- reimbursement payment must be made within 30 calendar days of the billing date, and
- warranty must be in accordance with the Special Specifications Item 6005, "Testing, Training, Documentation, Final Acceptance and Warranty."

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#### 4. MEASUREMENT

This Item will be measured as each unit furnished, installed, made fully operational and tested in accordance with these Special Specifications.

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#### 5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Embedded LED Dynamic Message Sign System (DMS)" of cabinet mounting type specified (pole mounted, foundation mounted, or wall mounted). This price is full compensation for furnishing, transportation and installation of Embedded LED DMS and its equipment cabinet; furnishing and installing any new mounting hardware, and Embedded LED DMS controller cabinet foundation when required; storing the Embedded LED DMS when required; cleaning and testing the Embedded LED DMS; replacement "and" or "or" repair of damaged components; disposal of unsalvageable material and for all manipulations, labor, tools, working drawings, equipment, and incidentals. This price is full compensation for furnishing, placing, and testing all materials and equipment, and for all tools, labor, equipment, hardware, operational software packages, supplies, support, personnel training, shop drawings, documentation, and incidentals.