SPECIAL SPECIFICATION

6024

Fiber Optic Dynamic Message Sign System

1. **Description.** Furnish and install fiber optic dynamic message sign (DMS) systems with nominal 8-in., 12-in., and 18-in. characters.

2. **Materials.** Provide new, corrosion resistant materials. Furnish, assemble, fabricate, and install materials as shown on the plans, the requirements of this Item, and to the pertinent requirements of the following Items:
   - Special Specification, “Electronic Components,”
   - Special Specification, “National Transportation Communications for ITS Protocol for Dynamic Message Signs,”
   - Special Specification, “Limited Distance Modem,”
   - Special Specification, “Dial-Up Modem” and,

Furnish the following equipment at each DMS field site shown on the plans:
   - Fiber Optic DMS,
   - Sign controller and cabinet, and
   - Cabling, modems and connectors from controller to sign.

Provide telephone voice communication type line circuit with telephone jack and wall telephone for voice communications. Install one jack/telephone with headset in each cabinet.

A. **Terminology.** This section defines the following specific terms as they apply to this Item:
   - Sign: The sign housings and their contents.
   - Sign Controller: Located in a cabinet, the sign controller specifies the message to be displayed. The message can be selected either remotely from the master controller or locally from a laptop computer.
   - Master Controller: The Microsoft Windows Server current release as supported by the Department’s Information System Division computer system and related software which operates the system.
   - Laptop Computer: This computer can operate both as a remote terminal and a maintenance terminal. As a maintenance terminal, the Laptop computer can connect to the sign controller and run diagnostic tests on the sign or select messages for that sign. As a remote terminal, the laptop can dial-in to the master
controller and gain full access to all of its functions. Include all equipment diagnostic and provisioning software for the laptop.

- Dot: Any of the small discreet elements that, when arranged in a 5x7 matrix, create a character. A dot includes 2 fiber optic bundles in a 12-in. or 18-in. character or 1 fiber optic bundle in an 8-in. character.
- Pitch: Distance measured from center to center of adjacent dots within a character. This distance can be measured both horizontally and vertically.
- Message: Text; the information shown on the sign.
- 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 at an operator-specified rate (a flashing display).
- Scenario: A preset plan, which specifies certain displays for a selected set of signs.
- Neutral State: Sign is blank or a predefined message is displayed.
- XHHW: High temperature 167°F Wet or 194°F Dry cross-linked polyethylene jacketed small diameter building wire.

B. Dynamic Message Sign. The Fiber Optic DMS must enable the display of text, consisting of a string of alphanumeric characters. The size of the sign must be as shown on the plans. Form each character by a matrix of 35 luminous dots over 5 columns and 7 rows. A luminous dot includes the ends of 2 fiber optic bundles for 12-in. or 18-in. characters or 1 fiber optic bundle for 8-in. characters. Fit the fiber ends with a convergence cone or lens. Use an electromagnetically controlled shutter mechanism to open and close the opening in front of the fiber optic bundles.

When required, provide flashing beacons as shown on the plans.

1. Physical Characteristics.
   a. General Construction. Manufacture and construct each line as an independent housing.

   Include an independent built-in tilting mechanism for each sign.

   Provide mechanical couplings between housings. Allow no passage of light between housings. Use a continuously welded aluminum alloy for the structure of each housing. Bolt aluminum alloy extrusions to the structure to form a housing envelope. Use a clear, anodized aluminum finish on each housing.

   Design and construct each sign to present a clean and neat appearance. Protect equipment within each sign from moisture, dust, dirt and corrosion. construct the sign with 1/8 in. thick 3003-H14 aluminum alloy or an approved equivalent. Use alloy 6061-T6 aluminum for framing structural members. Use an inert gas process for continuously welded seams.

   Securely clamp cables in sign housings with cable attachments. Do not use adhesive attachments.
Surround each 12-in. character and 18-in. character signs with a matte black 12 in. minimum aluminum border. Surround each 8 in. character signs with a matte black 24 in. minimum aluminum border. Painted surfaces will not be permitted.

Equip each sign housing with at least three 120V (±10%) grounded GFCI protected duplex electrical receptacles. Locate 1 receptacle at each end of the sign housing and 1 at the center of the sign housing.

Provide a voice communication circuit from the sign to the sign controller cabinet. Provide a telephone jack at an approved location in the sign. Store a telephone headset with microphone and a 50 ft. coiled cord in an approved location in the sign. Provide a telephone headset with sound dampening earphones and hands-off operation.

Design the sign enclosures to withstand wind loadings of 120 MPH, or as shown on the plans, without permanent deformation.

Ensure the performance of the signs will not be 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 ambient magnetic 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 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.

b. **Front Panel.** Protect the characters with a 1/4 in. thick, anti-reflection treated polymethacrylate of methyl faceplates or by 1/8 in. thick, nonbreakable, anti-reflection treated polycarbonate faceplates. To increase the contrast ratio, apply a matte black material to the faceplate exterior in all areas not directly in front of a display dot. Equip each character module with 100 watts of thermostatically controlled heat strips. Panels must not exceed a dimension of three characters in width.

c. **Accessibility.** Provide lockable inspection doors at the front or rear of the housings as shown on the plans. Provide 1 door per every 3 characters of nominal 12-in. or 18-in. character height, and every 6 characters of nominal 8-in. character heights.

Include a device to hold the door open in a 90°, 135°, and 165° position. Inspection doors must be interchangeable between lines of the sign.

d. **Character Modules.** Assemble character modules consisting of nominal 12-in. or 18-in. characters into a frame of 3 characters. Assemble character modules consisting of nominal 8 in. characters into a frame of 6 characters.

Provide a lamp assembly, fiber optic bundles, a transformer, and characters composed of a 5x7 matrix for each character module.
Provide a metal backplate covering the fiber bundles on the back of each character module. Character modules without a protective metal backplate will not be accepted.

Design the character modules for interchangeability with modules of the same size.

Provide for the replacement of a complete character module without the use of any tools. Use connectors for interconnection of modules. Provide a left-sided hinged side opening for each character module.

2. **Optical and Electrical Characteristics.**

   a. **Lamp Assembly.** Provide two 50 watt quartz halogen lamps per every 3 characters for the nominal 12-in. or 18-in. sign and per every 6 characters for the nominal 8-in. sign. One lamp is the “primary” lamp and the other is the “backup” lamp.

   Provide the possibility to light the “primary” and “backup” lamps simultaneously (“overbright” mode operation) to increase the light output level of each dot to overcome unfavorable conditions such as fog or intense sunlight.

   To prevent dazzling at night, reduce the voltage of the lamp to lower the light output level.

   Provide automatic switching from the “primary” to the “backup” (and vice versa) in the event of failure.

   Provide lamps with a maximum lamp voltage of 12 V. and an average service life of 6,000 hr. as rated by the manufacturer.

   Design the lamp and reflector as a single unit.

   Design the lamps to allow service without the use of tools.

   Provide detection for out-of-service lamps by the sign controller and report to the DMS Master Controller.

   Mount the lamp assemblies on vibration absorbing platforms.

   Supply yellow color filters as a part of the light projection assembly. Light output color must be field changeable without the use of tools.

   b. **Fiber Optic System.** Use step index glass optical fiber.

   Provide spare bundles with each fiber optic harness equivalent to 4% of the total bundles used per module. Jacket fiber bundles to protect them from damage.

   Fit each optical fiber light guide end with a minimum 0.16 in. in diameter convergence cone or lens. The cone or lens must produce a small emission controlled angle and must increase intensity axially.
The light intensity of each dot, at a distance of 1 ft., must be 20 candles under normal display brightness. No reflective material must be used to achieve 20 candles other than the pure light source.

c. Electromagnetic Shutters. Control the electromagnetic shutters by electrical pulses and must remain in their selected state after the applied pulse.

In a stable position, provide for zero consumption of electrical power by the shutters.

Base each shutter mechanism on a rotating device along the main axis to reduce inertia and increase reliability.

Accept a minimum of 2 fiber optic bundles by each shutter mechanism.

Prevent the passage of any light by the shutter mechanism. No light leakage is permissible at the maximum light intensity level.

Provide a maximum applied voltage to the shutters of 48 VAC or DC.

The manufacturer must demonstrate an efficient shutter mechanism designed for blocking the passage of light when the shutter is in the closed position. The light blocking mechanism must not be more than 1/8 in. from the light source when in the closed position unless otherwise approved.

d. Sign to Cabinet Interconnection. Provide cables between the sign and the sign controller cabinet. Terminate these cables on screw indexed terminal blocks at both ends.

Provide XHHW type cables and sized as required by the NEC for acceptable voltage drop to supply power to the lamps and the shutter controls.

3. Characters Displayed. Provide signs capable of displaying ASCII characters 32 through 126 (including all upper and lower case letters and digits from zero to nine) at any character location. Substitute a special graphics character for any of these characters as shown on the plans. If a substitution occurs, supply appropriate key covers.

Display the upper case alphanumeric characters over the complete height of the matrix. Submit character fonts for approval.

Provide rectangular matrices with an identical vertical and horizontal pitch between dots.

The separation between the last column of 1 matrix and the first column of the next must be equal to at least 2 times the horizontal distance between the columns of a given matrix.

Provide characters visible under all light conditions at a full distance, as described below, within a 12° cone of vision centered on the optical axis.

The nominal 8-in. high characters must be as follows:
The pitch must be 1.1 in. (± 0.0625 in.), and
All characters and symbols must be clearly visible and legible from a distance of 400 ft. minimum, along the axis.

The nominal 12-in. high characters must be as follows:
The pitch must be 3 in. (± 0.0625 in.), and
All characters and symbols must be clearly visible and legible from a distance of 800 ft. minimum, along the axis.

The nominal 18-in. high characters must be as follows:
The pitch must be 2.5 in. (± 0.0625 in.), and
All characters and symbols must be clearly visible and legible from a distance of 1,000 ft. minimum, along the axis.

4. **Number of Characters.** Provide the number of rows and characters per row as shown on the plans. A sign must display equally spaced characters arranged in equal rows of characters.

5. **Environmental Behavior.** Provide signs capable of operating without any decrease in performance over an ambient temperature range of -13°F to +149°F with a relative humidity of up to 95%.

Fit the signs with filtered ventilation louvers and replaceable filtered water drains.

C. **Sign Controller.** Supply a software-oriented microprocessor sign controller and with resident software stored in non-volatile memory. Provide an EEPROM of sufficient size to hold 12 messages and a test pattern in the sign controller.

Design the sign controller for fail-safe prevention of improper information display in the case of a system malfunction.

Failure of any sign must not affect operation of any other sign in the system.

Provide a 19 in. rack mountable sign controller with the following:
- Local control panel status indicators, including: power on/off, communications status, and controller address
- Power Supply Module,
- Central Processor Module,
- Shutter Driver Module(s), and
- Lamp Control Module(s).

Include an inter-PCB (printed circuit board) connection bus in the rack, carrying signals and power, onto which all PCB’s are connected. Use industry standard, keyed type connectors with a retaining mechanism for connections from the controller.

Provide maintenance personnel with a clear visual indication of DMS sign lamp status at the ground mounted field controller, without having to plug in a laptop, or contacting
the District Operations Center. Install light emitting red/green status indicators on the DMS controller front panel. Provide indicators for information on sign lamp status, regardless of whether or not the sign is displaying a message. Provide precise information as to the exact location of any non-functioning lamp on the sign.

1. **Sign Controller Cabinet.** Locate the controller cabinet as shown on the plans and with the following subassemblies:
   - Outer key lockable, protective enclosure,
   - Inner key lockable, non-vented enclosure,
   - Sign controller,
   - Local control panel,
   - 19 in. rack,
   - Communication equipment and a transient voltage surge suppressor (TVSS),
   - Power supply and power distribution,
   - Lamp driver system,
   - Photoelectric controller devices,
   - Internal cabinet heating, as required by the plans, and
   - Phone Jack.

Provide controller cabinet and its sub-assemblies capable of operating without any decrease in performance over an ambient temperature range of -13°F to +149°F without requiring fans or heaters.

a. **Protective Enclosures.** Provide a double enclosure type controller cabinet meeting the following:

   Fabricate the cabinet using unpainted aluminum with a minimum thickness of 1/8 in. Do not use any wood, wood fiber products, or other flammable material in the cabinet. Provide neat and uniform welds.

   Seal cabinet to prevent the entry of water. Seal unwelded seams with a clear or aluminum colored weather-seal compound.

   Fit the external enclosure with louvers ensuring natural cooling.

   Provide an internal enclosure complying with the NEMA type 3S standard (IEC 55). Provide a cabinet door with a catch mechanism with 2 positions of 90 deg. and 180 deg. for the external enclosure. Provide a cabinet door with a catch mechanism with a 90 deg. position for the internal enclosure.

   Design the internal cabinet dimensions to not exceed an overall volume of 20 cu. ft. The overall height of the internal cabinet must not exceed 60 in. above the top of the concrete foundation unless otherwise approved. Provide a detailed explanation of the theory of operation of the internal/external cabinet design explaining how the configuration will ensure natural heating and cooling.
Fit both internal and external enclosures with Corbin 2 lockable access doors. Key both locks alike. Supply all cabinets from the same manufacturer.

Base mount the external cabinet on a concrete foundation as shown on the plans.

House the transformer supplying power to the lamps inside the external cabinet but outside the internal cabinet enclosure.

b. **Main Power Supply and Energy Distribution.** Design the sign and its controller for use on the following:

- **Power Line Voltage** – 120 VAC Nominal - the system must operate within a voltage range of 95 VAC to 135 VAC.
- **Frequency** – 60 Hz ±3Hz.

Under normal operation, the drop in voltage between no load and full load of the sign and its controller must not exceed 10% of the nominal voltage.

Do not exceed the following power requirements for sign operation:

- 100 watts for the controller cabinet,
- 50 watts (one lamp) for every 3 characters in day mode, or 100 watts in overbright mode for the nominal 12-in. or 18-in. character height,
- 50 watts (one lamp) for every 6 characters in day mode, or 100 watts in overbright mode for the nominal 8-in. character height, and
- 1800 watts for thermostatically controlled heat strips on faceplates.

Provide power protection by a thermal magnetic circuit breaker associated with a 300 mA ground fault circuit interruption (GFCI) device. Install a GFCI device on all service outlets.

Protect the system by a transient voltage surge suppressor (TVSS).

c. **Lamp Drive System.** Provide a system with the following to power the lamps:

- A transformer to supply voltage to the lamps. Equip the transformer with taps enabling voltage adjustment to correct input voltage and compensate for the voltage drop between the controller cabinet and the sign.
- Relays for switching between the “day” and “night” light output levels,
- A static “on/off” relay, which must control overall extinguishing of the sign lamps (see Section 2.C.4.a., “Lamps Test”),
- Protection against overcurrent and short-circuits at the transformer secondary level, and
- Relays for the above must be “Solid State” relays when possible. Provide Static discharge protection for all relays.
d. **Sign Controller Communication Interface.** Provide 2 separate EIA RS-232D serial interfaces in the sign controller for communication with the DMS Master Controller and the laptop computer.

One EIA RS-232D serial interface must drive asynchronous modems for full duplex communication over dial-up lines or on a multi-drop network. Switching between dial-up and multi-drop operation must not require software modification.

Acquire and bear the charges of installing and connecting the dial-up telephone line for dial-up operation. Provide all needed modems.

Permanently install a cable for communications between the laptop computer and the second EIA RS-232D serial interface inside the sign controller cabinet. The communications cable must be easily accessible when the cabinet door is open.

e. **Photoelectric Sensor Devices.** Provide 2 fully adjustable photoelectric switches with each controller. Provide 1 switch to change between “DAY” and “NIGHT” light intensity levels, and the other to control the “OVERBRIGHT” light intensity level.

Install 3 photocells on the sign. Install 1 photocell to measure the “DAY” and “NIGHT” threshold. Install the other 2 on the front and rear of the sign to measure the “OVERBRIGHT” threshold. Provide photocells that permit automatic light intensity adjustment.

f. **Lighting.** Provide a fluorescent lamp that turns on the lamp when the door is open and off when the door is closed.

g. **Voice Communications.** Provide telephone voice communication type line circuit with two telephone jacks and two telephones. Install one jack/telephone with headset in the DMS controller cabinet and install one jack/telephone with headset at the DMS. Locate jack and DMS as directed. Store both headsets in the DMS controller cabinet. Provide a 50 ft. cord with each telephone with headset.

2. **Sign Controller Functions.** The sign controller must be controlled from the DMS Master Controller or the laptop computer, which must specify the appropriate display.

Perform the following functions with the sign controller and its software:

a. **Display a message,** including:
   - Static messages,
   - Flashing messages, and
   - Alternating messages.

   It must be possible to separately vary the flashing and alternating frequency. The flashing frequency must vary between 0.3 sec. and 2.0 sec. in 0.1 sec.
increments. The alternating frequency must vary between 0.5 sec. and 8.0 sec.
in 0.5 sec. increments.

b. **Report errors and failures**, including:
   - Data transmission error,
   - Receipt of invalid data,
   - Communications failure recovery,
   - DMS sign controller failure,
   - Power recovery, and
   - Lamps status.

c. The sign controller must blank any message displayed in the event of power or
   sign controller failure.

d. Out-of-service lamps must be detected by the sign controller and reported to
   the DMS Master Controller.

e. Switching from the “primary lamp” to the “backup lamp” (and vice versa)
   must be automatic in the event of failure.

f. If a primary lamp and the associated backup lamp are both not operational, the
   controller must turn off the entire sign.

g. In the event that a lamp does not turn off on command, the controller must
   automatically turn off the lamp power supply.

h. The sign controller must turn off the lamps during sign erasure and writing
   periods and when the sign is blank.

i. When the display time of a message has expired, the controller must set the
   sign to neutral. A sign is considered neutral when the sign is blank or a default
   (predefined) message in sign controller memory is displayed.

j. In the event of a communications failure with the DMS Master Controller, the
   sign controller must set the sign to neutral after a user-defined number of
   minutes unless communications have been restored within this period. This
   function must apply only when the sign controller is in the Master Control
   mode.

k. The DMS sign controller must have 12 messages and a test pattern stored in
   EEPROM. The DMS sign controller must be capable of displaying the
   EEPROM message indicated by the rotary switch on the Local/HOVL Control
   Panel when in LOCAL or HOVL mode.

l. The DMS sign controller must be capable of directing a test pattern, which will
   exercise each element in the sign from the rotary switch on the Local/HOVL
   Control Panel or from a command from the DMS Master controller.
m. The DMS sign controller must, at user programmed time intervals, activate all the shutters. This procedure must be used as a self-maintenance feature.

n. The DMS sign controller must be capable of reprogramming the messages stored in the EEPROM.

(1) **Message Loading.** Load the initial EEPROM message libraries at both the DMS Master Controller and the DMS sign controllers. The messages to be placed in these libraries will be furnished by the Engineer.

It must also be possible to write and download messages to the EEPROM libraries from the DMS Master Controller.

(2) **Lamp Control.** The sign controller must turn off the lamps during sign erasure and writing periods and when the sign is blank.

Flashing of a message must be controlled by turning the lamps on and off at a programmed speed.

3. **Modes of Operation.** The mode of operation determines which level of control governs the DMS message selection. The 3 modes of operation are:

- **Master** - the DMS Master Controller determines the appropriate message or test pattern.
- **Local** - the local control panel rotary switch or laptop computer is used to determine the appropriate message or test pattern.
- **HOVL** - the HOV Lane Control Panel rotary switch determines the appropriate message or test pattern (For HOV Lane DMS only).

a. **Local Control Panel.** Provide a Local Control Panel in the sign controller cabinet. Use waterproof switches on the panel with the following functions:

- **Control mode** - determines the DMS mode of operation (Master or Local).
- **Message selection** - rotary switch to select a blank message or any one of the EEPROM Messages stored in the DMS sign controller when Control mode is set to Local.
- **Message Implementation** - a push button switch to activate the message selected.
- **Test** - when in the Local mode of operation, activates the test pattern.

For non-HOV lane DMS, the mode of operation is determined by the position of the mode switch on the local control panel. If the switch on the local control panel is set to “Local,” the mode of operation is local. Otherwise, the mode of operation will be Master.

b. **HOV Lane Control Panel.** For each DMS located on an HOV lane, provided a HOV Lane Control Panel. Install the panel in a cabinet mounted on the DMS support structure or as shown on the plans.
For HOV Lane DMS, the mode of operation is determined by the position of mode switches on both the local control panel and the HOV Lane Control Panel. If the mode switch on the local control panel is set to “Local,” the mode of operation is local. Otherwise, the mode of operation will be either Master or HOV depending on whether the HOV Lane Control Panel switch is set to “Master” or “HOVL.” Use waterproof switches on the panel with the following functions:

- **Control mode** - determines the DMS mode of operation (Master or HOVL) when the Local Control Panel mode switch is set to “Master.”
- **Message selection** - rotary switch to select a blank message or any one of the EEPROM Messages stored in the DMS sign controller when Control mode is set to HOVL.
- **Message Implementation** - a push button switch to activate the message selected.
- **Test** - when in the HOVL mode of operation, activates the test pattern.

Do not include a display on the HOV Lane Control Panel. No AC power must be required. Supply all necessary voltages by the sign controller. Use low voltage discretes for signals between the HOV Lane Control Panel and the sign controller. The interconnection cable must be as shown on the plans. Install additional wires as required.

Install a telephone jack on the HOV Lane Control Panel to provide voice communications with the sign controller cabinet. Provide necessary portable headset and microphone compatible with the controller cabinet voice communications equipment.

4. **Safety of Operation.**

   a. **Lamps Test.**

      - **Primary mode** - All “primary” lamps are operational.
      - **Backup mode** - If a primary lamp is found not to be operational, the controller must automatically turn on the associated backup lamp.

      If a primary lamp and the associated backup lamp are both not operational, the controller must turn off the entire sign to prevent the display of an incomplete message.

      - **Abort** - In the event that a lamp does not turn off on command, the sign controller must automatically switch off the lamp power supply. The DMS Master Controller must also control this “Abort” function.

   b. **Primary Input Power Interruption.** Use material that meets the requirements of Section 2.1.4 “Power Interruption” of the NEMA Standard TS2, latest revision.
c. **Power Service Transients.** Use material that meets the requirements of Section 2.1.6 “Transients, Power Service” of NEMA Standard TS2, latest revision.

d. **Communications Link Failure.** In the event of a communications failure with the DMS Master Controller, the sign controller must set the sign to neutral after a defined number of minutes, as shown on the plans, unless communications have been restored within this period (whatever the remaining display time).

The function described above must apply only when the sign controller is in the Master Control Mode.

5. **Communications with DMS Master Controller.** The sign controller must be addressable by the DMS Master Controller via the communications system and in accordance with Special Specification, “National Transportation Communications for ITS Protocol for Dynamic Message Signs.” Protocol changes may be accomplished by changes to firmware, as needed.

Provide each DMS sign controller with error detection and reporting features, utilized to guard against incomplete or inaccurate transmission. These must include:

- Cyclic redundancy checking of all data received from the DMS Master Controller, with positive acknowledgement for all transmissions,
- Status monitoring for communication line malfunction or break, and
- Content validation of all received transmissions for logic or data errors.

Use point-to-point or multi-point communication line circuits and full duplex asynchronous data transmission at the rate directed by the Engineer within the range of 2400 to 19,200 bps. Provide necessary modems at each location.

Assign a unique address for each sign controller within the circuit to which the sign is connected. Encode data transmitted between the DMS Master Controller and the DMS sign controller in the ASCII representation using eight data bits, one stop bit and no parity. Use data transmissions in accordance with NEMA TS 3.3-1996 NTCIP Class B Profile.

Acknowledge all transmissions from the DMS Master Controller by the sign controller. Send a negative acknowledgement if an error is detected and a positive acknowledgement if no error is detected.

Submit any variations to the above requirements in writing for approval.

6. **Description of the Various Commands.** As a minimum, provide the following commands at the sign controller:

a. Display command from the DMS Master Controller (Master Control Mode).

b. Display command from the laptop computer (Local Control Mode).
c. Sign Status request - This command must provide a report concerning the following:
   • Sign appearance (lit, blank or neutral),
   • Lamp operating mode (primary/backup/abort),
   • Mode of the displayed message (local/HOVL/master),
   • Status of the photoelectric sensors,
   • Light output level (day/night/overbright), and
   • Sign number, location, or ID.

d. Lamp status request - This command must provide an instantaneous indication of the status of all the primary and backup lamps (operational/non-operational).

e. Day/Night switching command.

f. Overbright command.

g. “Abort” command

h. Sign off command (set to neutral or blank-out).

i. **Echo command.** This command must provide a report concerning the message currently displayed by the controller (texts, display parameters, remaining display time, received or memory resident messages).

j. **Simulation Command.** This command must turn off lights but controller continues to function in simulators.

k. **Message Display Time.** For each message, the operator must be able to define either a display time in minutes (maximum 65,000 minutes), or an unlimited display time. For alternating messages, the operator must be able to select a display time for each message and the blank-out time between the 2 messages in 0.5 sec. increments (from 0.5 sec. to 8.0 sec.).

D. **DMS Remote and Maintenance Terminal Software.** Supply 2 copies of the software with the following capabilities:
   • DMS startup
   • On site maintenance, that includes complete diagnostic of the sign
   • Remote Terminal functions
   • Display any message stored in the sign controller EEPROM or RAM
   • Create a new message to display on the variable message sign
   • Create and download messages to be stored in EEPROM
   • Start a “test pattern” display to check and verify each individual element of the sign
   • Create a non-volatile activity log
   • Dial-in to the DMS Master Controller and provide remote access to all DMS Master functions via the Remote Access Services.
3. **Construction.** Utilize the latest available techniques to minimize the number of different parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality. Design equipment for ease of maintenance. Component parts must be readily accessible for inspection and maintenance. Provide test points for checking essential voltages.

A. **Electronic Components.** Provide electronic components in accordance with Special Specification, “Electronic Components.”

B. **Mechanical Components.** Provide stainless steel external screws, nuts, and locking washers. Do not use self-tapping screws unless approved. Provide corrosion resistant materials and materials resistant to fungus growth and moisture deterioration. Separate dissimilar metals with an inert dielectric material.

C. **Documentation.** Provide sufficient documentation to reflect “as-built” conditions and to facilitate operation, maintenance, modification, and expansion of the system or any of its individual components. Manufacturer supplied documentation which covers the intent of this requirement may be used, as approved.

1. **Submittal Documentation.** Document each applicable equipment item or component in a manual. Submit 5 copies of the manual. Include the following information in the manual:
   - A general description of the equipment including all information necessary to describe the basic use or function of the system components and a general “block diagram” presentation of the equipment.
   - Where auxiliary equipment is required, include the nomenclature, physical and electrical characteristics, and functions of the auxiliary equipment in tabular charts. If shown elsewhere in the manual, refer to the location of the information pertaining to the auxiliary equipment.
   - The theory of operation of the system components in a clear, concise manner supported by simplified schematics, logic, data flow diagrams, one-function diagrams, etc. If required, include timing and waveform diagrams and voltage levels. Use a logical development starting with a system block level and proceeding to a circuit analysis. Detail circuit analysis whenever circuits are not normally found in standard textbooks. Describe the application of new theoretical concepts. Where the design allows operation in a number of different modes, include an operational description of each mode.
   - The routine of operation from necessary preparations for placing the equipment into operation to securing the equipment after operation. Include appropriate illustrations, with the sequence of operations presented in tabular form wherever feasible. Include a list of applicable test instruments, aids, and tools required in the performance of necessary measurements and techniques of each system component. Describe set-up test and calibration procedures.
   - The manufacturer's recommended procedures and checks necessary for preventive maintenance. Specify for pre-operation, weekly, monthly, quarterly, semi-annual, annual, and “as required” checks as necessary to assure reliable
equipment operation. Include tolerances for all electrical, mechanical, and other applicable measurement, adjustments, or both.

- 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 Section, 3.C.1. Describe accuracy’s, limits, and tolerances for all electrical, physical or other applicable measurements. Include instructions for disassembly, overhaul, and reassembly with shop specifications or performance requirements.

- Detailed instructions where failure to follow special procedures would result in damage to the equipment, improper operation, danger to operating or maintenance personnel, consumption of excessive man-hours, etc. Such instructions and specifications must be included only for such maintenance as may be accomplished by specialized technicians and engineers in a modern electro-mechanical shop. Describe special test setup, component fabrication, and the use of special tools, jigs, and test equipment.

- A detailed physical description of size, mass, special mounting requirements, electrical connections, and all other pertinent information necessary for proper installation and use of the equipment.

- The parts list with all information required to describe the characteristics of the individual parts, as required for identification. It must include a list of all equipment within a group and list of all assemblies, subassemblies, and replacement parts of units. The tabular arrangement must be in alphanumerical order of the schematic reference symbols and must give the associated description, manufacturer's name, and part number. A table of contents or some other convenient means, e.g., appropriate grouping, must be provided for identifying major components, assemblies, etc.

- Complete and accurate schematic diagrams as required to supplement the text material and to allow the books to be a self-contained technical information source. Limit the size of these diagrams to allow their use in close proximity of the equipment, in the classroom, etc., part reference symbols, test voltages, waveforms, and other aids to understanding of the circuit's function must be included on the diagrams. Test voltages, waveforms, and other aids to understand the circuit's function may be shown on both the simplified schematics and other drawings (as required in the above sections) on theory of operation or maintenance or on the schematic diagrams required for this section. The overall scope of information must not be less, however, than that stated for the schematic diagrams.

2. **Final Documentation.** Provide as-built final documentation for approval reflecting all change orders 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 in the cable diagrams and wiring lists.

Provide software, documentation, and intellectual property rights for the computer software system and components. These must include, but are not limited to, the following:
a. **Delivery.** Deliver 1 copy of the communication protocols used between the DMS Master and the DMS Sign Controller Software programs. Deliver 1 copy of all documentation supplied by the manufacturers for all plug in circuit cards used in the microcomputer chassis. Deliver 5 copies of narrative descriptions of software programs that describe the program name and the program's function.

b. **License.** Grant the Department a nonexclusive unrestricted license that will allow the Department to use, modify, or distribute any or all of the stated communication protocols and documentation.

D. **Technical Assistance.** Ensure that a manufacturer's representative is available to assist at each sign installation site and with installation of the DMS Master Controller. The manufacturer's representative must provide technical assistance in following areas:

- Sign to structure installation,
- Sign Controller cabinet installation, and
- Sign to controller cabling.

Do not execute the initial powering up of the signs without the permission of the manufacturer's representative.

E. **Training.** Provide operational and maintenance training in accordance with Special Specification, “Testing, Training, Documentation, Final Acceptance, and Warranty.”

F. **Testing Requirements.** Perform tests in accordance with Special Specification, “Testing, Training, Documentation, Final Acceptance, and Warranty.” Additional testing requirements are as follows:

1. **Verification of NTCIP Compliance.** The Department will verify, through use of the Department’s NTCIP Tester, that the equipment complies with the requirements of NEMA TS 3.3-1996 NTCIP Class B Profile and TS 3.6-1997 NTCIP Object Definitions for DMS.

2. **System Tests.** Conduct approved DMS system tests on the field equipment with the central equipment. The tests must, as a minimum, exercise all remote control functions and display the return status codes from the controller for a minimum of 72 hours. Approved data forms must be completed and submitted as the basis for review and for rejection or acceptance. If system tests fail because of any component in the subsystem, correct the particular component or substitute it with other components and repeat the tests. If a component is modified as result of the system test failure, prepare a report and deliver to the Engineer prior to retesting.

G. **Final System Acceptance.** Perform a final system acceptance in accordance with Special Specification, “Testing, Training, Documentation, Final Acceptance, and Warranty.”

H. **Requirements for Shop Drawings.** Submit 5 copies of shop drawings for approval before fabrication, include the sign structural members and attachment supports.
I. **References.** The sign manufacturer must submit 3 references, preferably Texas Department of Transportation, that have been successfully operating a fiber optic dynamic message sign system manufactured by this manufacturer, for a period of no less than one year. Include name and address of organization, and the name and telephone number of an individual from the organization who can be contacted to verify system operation for the reference data. Provide this information prior to documentation submittal. Failure to furnish the above references will be sufficient reason for rejection of the manufacturer's equipment.

J. **Warranty.** Provide a warranty in accordance with Special Specification, “Testing, Training, Documentation, Final Acceptance, and Warranty.”

4. **Measurement.** This Item will be measured as each unit furnished, installed, and tested.

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 “Fiber Optic DMS Field Equipment” of the size specified or “Fiber Optic DMS Master Equipment.” This price is full compensation for 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.