Florida Department of Transportation

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January 22, 2009

Monica Gourdine
Program Operations Engineer
Federal Highway Administration
545 John Knox Road, Suite 200
Tallahassee, Florida 32303

Re: Office of Design, Specifications
Section 781
Proposed Specification: 7810100 Intelligent Transportation Systems – Dynamic Message Signs

Dear Ms. Gourdine:

We are submitting, for your approval, two copies of the above referenced Supplemental Specification.

This change was proposed by Gene Glotzbach to include additional Dynamic Message Sign technology used for arterial and other applications that do not require a walk-in, full-size DMS.

Please review and transmit your comments, if any, within four weeks. Comments should be sent via Email to ST986RP or rudy.powell@dot.state.fl.us.

If you have any questions relating to this specification change, please call Rudy Powell, State Specifications Engineer at 414-4110.

Sincerely,

Signature on File

Rudy Powell, Jr., P.E.
State Specifications Engineer

RP/ft
Attachment
cc: Gregory Jones, Chief Civil Litigation
Florida Transportation Builders' Assoc.
State Construction Engineer

**INTELLIGENT TRANSPORTATION SYSTEMS–DYNAMIC MESSAGE SIGNS. (REV ~~84~~ *~~2016~~* ~~07~~*81-22-09*) ~~(FA 5-11-07) (1-08)~~**

ARTICLE 781-1 (of the Supplemental Specifications) is deleted and the following substituted:

**781-1 Description.**

Furnish and install Motorist Information Systems meeting the general requirements of 781-2, the specific requirements for each system as defined in 781-3 through 781-6 of this specification, and in accordance with the details specified in the Contract Documents. *Use only equipment and components that meet the requirements of these minimum specifications, and are listed on the Department's Approved Product List (APL).*

ARTICLE 781-3 (of the Supplemental Specifications) is deleted and the following substituted:

**781-3 Dynamic Message Sign*s*.**

**781-3.1 ~~Description~~*Dynamic Message Sign with 18" Character Display (18" DMS)*:** Furnish and install a*n 18" DMS*~~dynamic message sign (DMS)~~ in accordance with the details specified in the Contract Documents.

**781-3.1.1 General:** Ensure that all exposed material is corrosion resistant. Ensure that the electronic equipment associated with the *sign*~~DMS~~ remains secure from damage and protected from moisture, dust, dirt, and corrosion.

Ensure that ambient magnetic or electromagnetic fields, including those created by any system components, have no negative effects on system performance. Ensure that the system does not conduct or radiate signals that interfere with other electrical or electronic equipment including, but not limited to, other control systems and data processing, audio, radio, and industrial equipment.

Ensure that the ~~DMS~~*sign* housing complies with the fatigue resistance requirements of the ~~fourth~~ *fifth* edition ~~(2001)~~ AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals with current addendums. Design and construct the DMS unit for continuous usage of at least 20 years and the sign structure for a 50-year design life. *Ensure that equipment and structures are designed to withstand the wind loads defined in the FDOT Structures Manual without deformation or damage.*

Ensure that the ~~DMS~~*sign* is fabricated, welded, and inspected in accordance with the requirements of the current ANSI/AWS Structural Welding Code-Aluminum. Ensure that all identification markings on the ~~DMS~~*sign* and its components, including but not limited to panels, terminal blocks, and printed circuit boards, are silk-screened and sealed or otherwise indelible. ~~using material and methods approved by the Engineer. Ensure that equipment design and manufacturing utilizes the latest available techniques with a minimum number of different parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality.~~ Ensure that the equipment design~~ed includes provisions for~~ *allows* access

and maintenance without special tools. Ensure that all component parts are ~~readily~~ accessible for inspection and maintenance. Provide labeled test points for checking essential voltages. Ensure that all external connections are terminated using connectors. Key the connectors to preclude improper hookups. Provide a clear removable cover measuring 0.125 inch thick to cover all exposed power terminals. Ensure that the covers do not interfere with sign functions or maintenance operations.

**781-3.1.2 Sign Housing:** Ensure that the external skin of the ~~DMS~~*sign* housing is constructed of aluminum alloy 5052 H32 that is a minimum of 0.125 inch thick. Ensure that the sign housing design and appearance is approved by the Engineer. If cable attachments are used in the sign housing, the cables shall be securely clamped using a method approved by the Engineer. No adhesive attachments shall be allowed.

Ensure that exterior seams and joints, except the finish coated face pieces, are continuously welded using an inert gas welding method. Limit the number of seams on the top of the housing to a maximum of three. Stitch weld the exterior housing panel material to the internal structural members to form a unitized structure.

Ensure that exterior mounting assemblies are fabricated from aluminum alloy 6061 T6 extrusions a minimum of 0.1875 inch thick.

~~Provide mounting brackets on the sign housing that permit adjustment of the housing's vertical alignment from 0 to 10 degrees down in one-degree increments to optimize the viewing angle. Ensure that these vertical adjustments to the position of the sign housing do not require the removal of the housing from the support structure in order to achieve a different vertical orientation.~~*Ensure that sign provides a minimum legible viewing distance that includes the area from 100 to 1100+ feet in advance of the sign. Ensure that the sign is legible for a minimum of 10 seconds when viewed from an approaching vehicle moving at the posted speed.*

Ensure that the bottom panel of the sign housing includes a minimum of four drain holes with replaceable plugs that serve to open and close the drain. Ensure that the drain holes are centered from the front to the back of the housing, and equally spaced across the housing's full length. Ensure that all drain holes and other openings in the sign housing are screened to prevent the entrance of insects and small animals. Ensure that the bottom panels are sloped towards the drain holes to prevent water accumulation on the interior surfaces of the sign bottom.

Ensure that the top of the ~~DMS~~ housing includes multiple steel lifting eyebolts or equivalent hoisting points. Ensure hoist points are attached directly to structural frame members by the ~~DMS~~ *sign* manufacturer. Ensure hoist points are positioned such that the *sign*~~DMS~~ remains level when lifted. Ensure that the hoist points and ~~DMS~~*sign* frame allow the ~~DMS~~*sign* to be shipped, handled, and installed without damage.

**781-3.1.2.1 Interior Structure:** Ensure that framing structural members are constructed of aluminum alloy (6061 T6 or 6063 T5) a minimum of 0.1875 inch thick.

Construct the sign housing with a minimum width of 34 inches. Provide an interior walkway with a minimum width of 2 feet. Ensure that the walkway area maintains a minimum of 2 feet of horizontal clear area and 6 feet of clear

height along the sign housing's entire length. Fabricate the walkway from diamond tread plate 6061-T6 or 3003-H22 aluminum that is 0.125 inch thick. Finish all edges of the walkway to eliminate sharp edges or protrusions.

**781-3.1.2.2 Housing Face:** Ensure that housing face consists of internal structural members, external fascia panels, and lens panel assemblies. Do not allow exposed fasteners on the housing face.

**781-3.1.2.2.1 Internal Structural Members:** Ensure that internal structural members are constructed of extruded aluminum and accommodate both display module mounting and air distribution. Ensure that the internal structural members retain the display modules in a manner that facilitates the easy and rapid removal of each display module from within the sign without disturbing adjacent display modules.

**781-3.1.2.2.2 External Fascia Panels:** Ensure that ~~the~~ external fascia panels are constructed using aluminum. Ensure fascia panels *are sealed to prevent intrusion of water, moisture, dust, dirt, and other contaminants into the sign interior*~~incorporate provisions for retaining the modular lens panels. Include a gasket track in the panel for a closed-cell resilient gasket to seal the modular lens panels~~. Finish each fascia panel with a matte-black coating system that meets or exceeds American Architectural Manufacturers Association (AAMA) Specification No. 2605. Ensure that the external fascia perimeter panels are a minimum of 1 foot wide. Ensure that external fascia interline panels are a minimum of 9 inches wide.

**781-3.1.2.2.3 Lens Panel Assembly:** Provide lens panel assemblies that are modular in design, ~~*removeable*~~*removable, and* interchangeable without misalignment of the lens panel and the LED pixels, and that are removable from within the main sign housing. Ensure that lens panels *include*~~consist of~~ a mask constructed of 0.080 inch minimum thickness aluminum with a matte black coating that meets or exceeds AAMA Specification No. 2605 with a minimum thickness of 0.04 inch. Ensure that the mask is perforated to provide an aperture for each pixel on the display module. Ensure that the aperture*s are uniform, centered over each pixel, and* ~~is~~ as small as possible~~,~~ without blocking the LED output at the required viewing angle.

*Ensure the lens panel assembly consists of LEDs, other internal electronics, an aluminum mask, and an environmental shielding layer coating to protect and seal the LEDs and other internal electronics. The coating shall be a minimum 90% ultraviolet (UV) opaque.*~~Ensure that the lens panel includes a clear polycarbonate layer placed behind the mask to protect and seal the LEDs and other internal electronics from the environment. Ensure that the clear polycarbonate is laminated and sealed to the inside surface of the lens panel's aluminum mask using an adhesive joining system to form the lens panel assembly and that the clear polycarbonate used to construct the lens panel is 90% ultraviolet (UV) opaque. The Engineer may approve alternate designs.~~

**781-3.1.2.3 Sign Housing Surface Finish:** Ensure that all sign face surfaces are finished with a matte black FP-based coating system that meets or exceeds AAMA Specification No. 2605. Provide certification that the sign face parts are coated with the prescribed thickness. Ensure all other exterior and all interior housing surfaces are a natural aluminum mill finish. No interior painted surfaces will be allowed.

**781-3.1.2.4 Sign Housing Access Door:** Provide a three-point, lockable, aluminum access door at the end of the housing, as depicted in the plans, to

permit easy access to the walk-in housing. The access door shall be a minimum height of 80 inches and a minimum width of 2 feet. Outfit the door with a handle-operated locking mechanism, closed-cell neoprene gasket, and stainless steel hinges.

Furnish a locking mechanism that is a Grade 1 three-point, center-case dead bolt lock conforming to ANSI/BHMA Standard A156.2 and having a zinc finish. Provide a handle on both the inside and outside of the door. *Ensure that* ~~These~~ handles *are*~~shall be~~ heavy duty*,* ~~and~~ industrial strength*, and corrosion resistant* ~~with a zinc finish on the inside handle and a chrome finish on the outside handle~~. Include a device in the door assembly to hold the door open at 90 degrees. Ensure that the door is monitored electronically by the sign controller and provides an alert to transportation management center (TMC) personnel whenever the door is opened.

**781-3.1.2.5 Sign Housing Ventilation System:** Provide a ventilation system that distributes air over all LEDs, power supplies, and communication devices inside the sign housing. Ensure that air circulation is evenly distributed across display modules ~~in each message line~~, in the cavity between each display module, across lens panels and the back of the display modules. Submit ventilation system design calculations to the Engineer for approval.

Ensure that air drawn into the sign is filtered *upon entry*~~before reaching the ventilation system fans~~. Ensure that filters remove airborne particles measuring 500 microns in diameter and larger.

Ensure that the ~~airflow status for each fan and filter~~*ventilation system* is automatically tested once each day, and that it may be tested on command from *remote and local control access locations*~~the TMC or a laptop computer~~. Ensure that the sign controller will send an error message to the TMC or a laptop computer when a failure occurs. Ensure that the sign is capable of operating without any decrease in performance over an ambient operating temperature range of -29° to 165°F as per NEMA TS 4, Subsection 2.1.5.1, with a maximum relative humidity of 100%.

Ensure that the ~~DMS~~*sign* includes a fail-safe ventilation subsystem that includes a snap disk thermostat that is independent of the sign controller. Preset the thermostat at 130°F. If the sign housing's interior reaches 130°F, the thermostat will override the normal ventilation system, bypassing the sign controller and turning on all sign ventilation fans. The fans will remain under the control of the thermostat until the internal sign housing temperature falls to 115°F, at which time the fail-safe subsystem will return control of the ventilation system to the sign controller.

Ensure that the sign includes a manual override timer switch located just inside the access door to manually activate the ventilation system. The switch must be adjustable up to four hours.

Ensure that the sign includes a sensor or a sensor assembly to monitor airflow volume to predict the need for a filter change. Ensure that the ventilation system fans possess a 100,000-hour L10 life rating.

**781-3.1.2.6 Sign Housing Temperature Sensor:** Ensure that the sign controller continuously measures and monitors the temperature sensors. *Ensure that the sign can be programmed to blank* ~~W~~*w*hen a *user-defined critical* temperature is *exceeded*~~greater than the user-selectable critical temperature, ensure that the sign message will go blank and an error message will be sent to the TMC or a laptop computer when polled~~*. Ensure that the sign will report such events when polled*. Ensure that the

user-selectable, critical temperature may be changed by *remote and local control access*~~the TMC or a laptop computer~~. Ensure that ~~the~~ *remote and local* ~~TMC and laptop~~ computer*s can*~~will~~ read all temperature measurements from the sign controller. When the sign reaches a temperature that is 2°F lower than the critical high temperature, ensure that the sign controller will decrease the LED intensity to half its normal brightness.

**781-3.1.2.7 Sign Housing Humidity Sensor:** Ensure the sign includes a humidity sensor that detects from 0 to 100% relative humidity in 1% or smaller increments. Ensure that the sensor will operate and survive in 0 to 100% relative humidity, and has an accuracy that is better than ±5% relative humidity. A humidistat is not acceptable.

**781-3.1.2.8 Photoelectric Sensor Devices:** Ensure the sign electronics monitor ambient light using a minimum of three photocells. Ensure that the photocells are placed so they measure light levels on the front and rear of the sign, and ambient light conditions at the sign location. Ensure that the devices provide accurate ambient light condition information to the sign controller for automatic light intensity adjustment. Ensure that the automatic adjustment of the LED driving waveform duty cycle occurs in small enough increments that the sign's brightness changes smoothly, with no perceivable brightness change between adjacent levels. Ensure that stray headlights shining on the photoelectric sensor at night do not cause LED brightness changes.

Supply the ~~DMS~~ *sign* with a brightness-versus-ambient light matrix table with algorithms and/or other means of calculation that enables the sign to automatically adjust LED output according to ambient light level. Ensure the sign controller monitors the photocell circuits in the sign and correlates the readings with the brightness table to convert the measured light intensity into the desired pixel brightness. Ensure that the brightness table has a minimum of 255 levels. Ensure that the brightness table in each individual sign controller is adjustable from the TMC or a laptop computer, and can be customized according to each installation site's requirements. Ensure that the sign controller automatically controls the pixel brightness to compensate for differences in ambient light levels, such as the differences in day and night. In addition to the automatic mode, ensure that the brightness may be set from 1% to 99% in 1% increments manually from the front panel of the sign controller and remotely from the TMC.

Ensure that the brightness and color of each pixel is uniform over the sign's entire face within a 15-degree viewing angle from 200 to 1,100 feet in all lighting conditions. Non-uniformity of brightness or color over the sign's face shall be cause for rejection of the sign.

**781-3.1.2.9 Sign Housing Internal Lighting and Electrical Outlets:** Furnish the sign housing with a minimum of four internal fluorescent or incandescent light fixtures. Near the door, locate a 12-hour timer without a hold feature for the lights.

If incandescent lamps are provided, ensure that they are spaced evenly above the walkway and fully enclosed in heavy-duty shatterproof, protective fixtures. Ensure that incandescent fixtures include aluminum housing and base, a porcelain socket, and clear glass inner cover. Ensure that all removable components are secured with set screws.

If fluorescent lamps are provided, ensure that the fixtures are spaced evenly above the walkway and fitted with protective guards.

Ensure that the sign housing includes emergency lighting that automatically illuminates the interior in the event of a power outage.

Ensure that the light produced from internal lighting is not visible from outside the sign during nighttime or other dark conditions and does not interfere with normal visible operation of the sign.

Equip each sign housing with at least three 15-amp, 120-volt rated ground fault interrupter (GFI) outlets that include protected duplex electrical receptacles. Locate one duplex receptacle at each end of the sign housing and one at the center of the sign housing. Space the duplex receptacles evenly on the rear wall of the housing at a maximum height of 3 feet above the walkway.

**781-3.1.3 Display Modules:** Provide display modules manufactured by one source and fully interchangeable throughout the manufacturer's sign system(s). Ensure that *removal of a single display module does not impact the operation of other display modules*~~all addressing is automatic upon cable connection and power-up~~. ~~Ensure that the display modules are connected to the sign controller via a single control cable common to each line of display modules or by an alternate method approved by the Engineer.~~ Ensure that removal or replacement of a complete display module or LED board can be accomplished without the use of any tools.

~~Ensure that the Engineer approves the design and structural calculations of the spacing between the display module and the DMS lens panel.~~ Ensure display modules contain solid-state electronics needed to control pixel data and read pixel status.

**781-3.1.3.1 Line Matrix Display Module:** Assemble display modules in a line matrix configuration consisting of three lines of 25 display modules per line. Ensure each line consists of an array, 7 pixels high by 125 pixels wide, allowing an 18-inch-high display of 5 pixel by 7 pixel characters per line with double-column spacing between the characters. Ensure that the line matrix display module includes an LED board containing a minimum of 35 pixels in a 5 pixel by 7 pixel configuration capable of displaying 18 inch dot matrix characters.

**781-3.1.3.2 Full Matrix Display Module:** Assemble display modules to form a full matrix configuration consisting of three lines of 25 display modules per line providing an arrangement of 27 pixels by 125 pixels. Ensure that the display will allow an 18-inch-high display per line with 5 pixel by 7 pixel characters and double-column spacing between the characters. Ensure that the full matrix display module includes an LED board containing 45 pixels arranged uniformly in 5 columns of 9 pixels each to form a 5 pixel by 9 pixel array capable of displaying 18-inch dot matrix characters.

**781-3.1.3.3 LED and Pixel Specifications:** Ensure that the ~~DMS~~*sign* utilizes amber, three-quarter diode LED lamps with a minimum viewing angle of 15 degrees and a peak wavelength of 590 nanometers. Ensure that the LED peak wavelength output varies no more than ±2 nanometers. Ensure that the LED pixel cone of vision is a minimum of 15 degrees (centered around the optical axis, or zero point, of the pixel). The cone perimeter is defined by the point where light output intensity is 50% of the intensity measured at the zero point of the pixel.

Ensure that each pixel has a diameter of 1.5 inches, ±10%, and that the LEDs in each pixel are clustered to maximize long-range visibility. Ensure that all pixels in all signs in a project, including operational support supplies, have equal color and on-axis intensity. Ensure that each pixel's on-axis intensity is a minimum of 40 candelas when operating at 100% intensity. Measure the brightness of each LED in accordance with the International Commission on Illumination's (CIE) requirements as detailed in Test Method A of the CIE 127 (1997) standard. Provide the LED brightness and color bins that are used in each pixel to the Engineer for approval. Provide a letter of certification from the LED manufacturer that demonstrates testing and binning according to the CIE 127 (1997) standard.

Ensure each pixel contains two interlaced circular strings of LEDs powered from a regulated power source providing a maximum of 25 volts of direct current ($V_{DC}$). Ensure that LED power current is maintained at 25 milliamperes, ±2 milliamperes. Ensure that LED failure in one string within a pixel does not affect the operation of any other string or pixel. Do not exceed 1.5 watts per pixel for power drawn from a direct current (DC) supply, including the driving circuitry.

Provide a pixel test as a form of status feedback to the TMC from the local sign controller. Ensure that the operational status of each pixel in the sign can be automatically tested once a day. The operational status may also be tested when the TMC or a laptop computer prompts a pixel test. Ensure that a log file can be created containing a list of defective pixels as transmitted to the TMC or a laptop computer. Ensure that the log file includes the pixel status, module number, column number, and pixel number. Ensure that the pixel status test determines the functional status of the pixel as stuck-on or stuck-off and does not affect the displayed message for more than half a second.

Ensure that LEDs are individually mounted directly on a PCB, and are individually removable and replaceable using conventional electronic repair methods. ~~Do not use pixels in which the LEDs are encapsulated.~~

**781-3.1.3. 4 Optical, Electrical, and Mechanical Specifications for Display Modules:** Ensure that each display module contains connectors for power, controls, and data; contains display module control electronics and memory elements; and provides the signals to switch the LED pixels.

Ensure the display modules are rectangular and have an identical vertical and horizontal center-to-center distance (i.e., pitch) between adjacent pixels ranging from 2.6 inches to 2.75 inches. Ensure that the separation between the last column of one display module and the first column of the next module is equal to the horizontal distance between the columns of a single display module.

Ensure that the LED circuit board is a NEMA FR4-rated, single 0.062-inch, ~~flat~~ black PCB ~~having an extruded aluminum frame and will hold the supporting control electronics~~. Ensure that alternate LED board configurations are submitted to and pre-approved by the Engineer prior to installation. Ensure that PCBs enable components to be removed and replaced without damage to boards, traces, or tracks. Ensure that the intercomponent wiring is a copper-clad track having a minimum weight of 2 ounces per square foot with an adequate cross section for carrying circuit current. Ensure that *no PCB has more than* ~~a maximum of~~ two PCB jumper wires ~~are used~~

~~from plated through holes to the component~~*present*. Finish all PCBs with a solder mask and a component-identifying silk screen.

Provide all PCBs, except for the LED motherboard and power supply PCBs, with a complete and conformal coating of silicone resin with a minimum thickness of 0.01 inch. Provide the LED motherboards with a complete conformal coating of silicone resin with a minimum thickness of 0.01 inch, except for the pixels on the front of the PCB. Meet the material requirements of MIL-I-46058C Military Standard, United States Department of Defense (USDOD).

Mount all LEDs so that the mechanical axis of the LED is ±1 degree to the sign's face to ensure uniformity of brightness over the sign's face. ~~Each pixel shall have a device attached to the PCB to hold and protect the LEDs~~. Ensure that ~~the devices hold the~~ LEDs *are secured* perpendicular to the display module within 0.5 degree and may be easily removed from the display module PCB without tools. Ensure that ~~the~~ *any* devices *used to secure LEDs* do not block air flow to the LED leads or block the LED light output at the required viewing angle. Ensure that *all components on the LED side of PCBs*~~the devices~~ are black ~~in color~~.

Ensure that the voltage to the LED modules and their associated electronics does not exceed 25 $V_{DC}$. Ensure that there are a minimum of two, and a maximum of four, power supplies that are wired in a parallel configuration for redundancy. Ensure that multiple power supplies are used to provide power to each display module. Ensure the voltage measured at the display modules does not vary more than 50 millivolts over all the display modules in the sign with 17 pixels on at 100% intensity in each display module. Ensure that if one supply completely fails, the sign shall still be supplied with enough power to run 40% of all pixels at a 100% duty cycle with an ambient operating temperature of 165°F. Ensure that the supplies have a current sharing capability that allows them to provide equal amounts of current to their portion of the LED display.

Ensure that the sign controller continuously measures and monitors all LED module power supply voltages and provides the voltage readings to the TMC or a laptop computer on command. Ensure that an error message will be sent to the TMC or a laptop computer when it polls the sign controller if voltages measured are outside nominal values.

Ensure that LEDs are protected from external environmental conditions, including moisture, snow, ice, wind, dust, dirt, and UV rays. Do not use hoods, louvers, cylinders or visors that could impede the free flow of air over any surface of each individual LED. Do not use epoxy to encapsulate the LEDs.

**781-3.1.4 Character Displays:** Ensure that the signs are capable of displaying American Standard Code for Information Interchange (ASCII) characters 32 through 126, including all uppercase and lowercase letters and digits 0 through 9, at any location in the message line.

Ensure that the uppercase alphanumeric characters are displayed over the complete height of the matrix. Submit a list of the character fonts to the Engineer for approval.

Characters must be legible under all light conditions at a distance ranging from 200 to 1,100 feet within the 15-degree cone of vision centered on the pixel's optical axis. Ensure that the operator is able to display compressed (i.e., 4 pixel by

7 pixel), expanded (i.e., 6 pixel by 7 pixel), or double-stroke (i.e., 7 pixel by 7 pixel) character fonts, and to change the default spacing between characters. Ensure that the spacing options include 1-, 2-, or 3-pixel columns between the characters. ~~Have~~ *Ensure* the system *is loaded with a default font in accordance with the Standard Font set described in NEMA TS4-2005 (section 5.6). Ensure the system allows the assignment of* ~~supervisor assign~~ font access privileges. Ensure that the sign controller is capable of a self-updating time~~, temperature,~~ and/or date display on the sign.

Ensure that the sign controller allows a moving arrow to be displayed on one line with a standard *text* message on the other lines. Ensure that the moving arrows may be shown moving from the left or right, and starting from one end or in the middle of the sign and continu*ing*~~e~~ to the end of the sign.

**781-3.1.5 Main Power Supply and Energy Distribution Specifications:** Provide a nominal single-phase power line voltage of 120/240 $V_{AC}$ protected by one 60-amp, two-pole (i.e., common trip) main circuit breaker for the sign and its controller. Ensure that the system operates within a voltage range of 97 to 135 $V_{AC}$ as specified in NEMA TS 4, Subsection 2.1.3.1.

Ensure that all service lines inside the sign housing are supplied by 120 $V_{AC}$ independently protected by a thermomagnetic circuit breaker at the sign housing's entry point. Locate all 120 $V_{AC}$ wiring in conduit, pull boxes, raceways, or control cabinets as required by the NEC. Ensure that no 120 $V_{AC}$ wiring is exposed ~~to the~~ inside or outside of the sign housing. Do not use the sign housing as a wiring raceway or control cabinet.

Ensure that the sign and its controller have an operating frequency of 60 hertz (Hz), ±3.0 Hz, as stated in NEMA TS 4, Subsection 2.1.3.2. Ensure that the drop in the unit's voltage between no-load and full-load during normal operations does not exceed 10% of the nominal voltage. Provide power protection through the use of a thermomagnetic circuit breaker connected to a 5-milliampere GFI device that protects all service outlets. Provide a 100-amp 120/240 $V_{AC}$ two-pole load center with a 20-circuit capability. Provide separate circuit breakers for each sign circuit.

Provide Type XHHW power cables sized as required by the NEC for acceptable voltage drops while supplying alternating current to the sign. Ensure that the sign power consumption does not exceed 7,000*VA* ~~watts~~ under any circumstance, including operation of the fans, heaters (if provided within the sign), sign controllers and communication equipment, and all pixels illuminated at 100% brightness.

Provide protection devices such as surge suppressors and lightning arrestors installed or incorporated in the *sign system*~~DMS~~ by the manufacturer to guard against lightning, transient voltage surges, and induced current. Ensure that the protection devices meet or exceed the device protection requirements as contained in Section 785-2. Use protection devices on all electric power and data communication connections.

Ensure that the DC and AC voltage ratings and dissipation factors of capacitors used in the ~~DMS~~ *sign system* exceed the worst-case design parameters of the circuitry by 50%. Ensure that capacitors *that are not surface mount components* are mechanically supported by a clamp or fastener that is resistant to cracking, peeling, and discoloration.

Ensure that resistors used in the *sign*~~DMS~~ are within 5% of the tolerance of the specified temperature range and, when operated in excess of 50% of its power rating, have an adequate heat sink.

Ensure all transistors, integrated circuits, and diodes are a standard type, listed by the EIA, and clearly identifiable.

**781-3.1.6 Uninterruptible Power Supply:** Provide each *sign*~~DMS~~ with an uninterruptible power supply (UPS) capable of maintaining and continuing the operation of the sign and its related communication device for a minimum of two hours. Provide sealed AGM type batteries that are maintenance free. *Ensure that the UPS is installed within the sign housing or as shown in the plans.*

**781-3.1.7 Operational Support Supplies:** Furnish the operational support supplies listed in the table below. Promptly replace any of the supplies used to perform a warranty repair.

For every group of 10 or fewer *18" DMS*~~signs~~ provided or required, provide 1 set of supplies as follows:

| | |
|---|---|
| 1 each | Sign Controller |
| ~~3~~ *10* | LED Display Modules |
| ~~3~~ *1* | Uninterruptible Power Supplies |
| 1 each | System Interface Circuit |
| 1 each | Cable for connecting interface circuits to daughter boards |
| 1 each | Display Module ~~Power~~ Cable*s* |
| 2 each | Surge Suppression Sets |
| 1 each | Fan Assembly |
| 1 each | Time Relay for Fan Control |
| 10 each | Every Small Fuse (< 10 amp) |
| 2 each | Every Large Fuse (> 10 amp) |
| 1 each | Sensor for each type of sensor |

The Engineer will review and approve the operational support supplies~~ list.~~.

**781-3.1.8 Sign Controller:** Ensure that the sign is provided with a sign controller that includes operational firmware stored in nonvolatile memory. Program the controller to receive sign control commands from the TMC, to transmit responses (as requested) to the TMC, and to control sign operation and message displays. Ensure that sign controller functions include error logging and reporting, and providing the

operational status of the sensors including temperature, photocell, airflow, humidity and LED power supply sensors.

Ensure that the sign controller will read the internal temperature sensors, the external ambient temperature sensors, and the humidity sensors and use the readings in an algorithm that turns on ~~the~~ heat tape and/or ~~the~~ fans *when conditions warrant*~~at the appropriate times~~ to prevent ~~both~~ frost on the face of the sign~~,~~ and condensation on the display modules and other electronic circuitry.

Ensure that the sign controller receives and sends messages by way of an Ethernet network ~~using the system's fiber optic cable plant~~ and that the failure of any sign does not affect the operation of any other sign in the system.

Ensure that, at a minimum, the sign controller consists of local control panel status indicators including power on/off, TMC communication status, laptop computer communication status, communication status with the electronics in the walk-in housing, ~~sign display power supply status, pixel error status, controller address, power supply module, access door alarm, central processor module, and input and output circuits~~*and sign diagnostics and error status*.

Ensure that the controller provides power-up and automatic restart capabilities with automatic sign blanking when recovering from a power-off condition. *Ensure that the sign can be configured to either display a stored message or blank upon recovery from power loss and upon recovery from system resets.* Utilize a hardware watchdog circuit to provide automatic *recovery from critical errors and automatic*~~sign~~ shutdown in the event of *critical hardware* ~~power or sign controller~~ failure.

Mount the sign controller within the sign housing using industry standard keyed-type connectors with a retaining mechanism. *Ensure that there is a ground level access point at the sign location that allows the sign to be programmed and controlled locally using a laptop computer.*

**781-3.1.9 Display System Hardware:** Ensure the ~~DMS~~ *sign* utilizes a system *data* interface circuit for communication between the sign controller and display modules ~~consisting of data bus drivers and line address decoders~~. *Ensure* ~~*that*~~ Mount the following components *reside* inside the ~~DMS~~ walk-in housing: sign controller, display system interface circuits, display modules, power supplies, local and remote control switches, LED indicators, an Electronic Industries Alliance (EIA)-232 plug-in connection for laptop computers, EIA-232 null modem cables (minimum of 4 feet long for connecting laptop controller to sign controller), ~~a UPS system,~~ workspace for a laptop computer, and communication equipment and transient voltage surge suppressors.

**781-3.1.10 Control Cabinet Specifications:** Provide a ~~single door NEMA 3R~~ control cabinet that meets the requirements of Section 785-4.

Equip the ground control cabinet with the following assemblies and components, *unless otherwise* ~~as shown~~*specified* in the plans: power~~ on~~ indicator~~s~~, surge suppression on both sides of all electronics, ~~waterproof local/remote switches and LED indicators,~~ communication interface devices, ~~EIA-232~~ connection~~s~~ for *a* laptop computer~~s~~ *for local control and programming*, ~~EIA-232~~ cables a minimum of 4 feet long to connect laptop computers, and duplex outlets.

Provide for all telephone, data, control, *power,* and confirmation connections between the sign and ground control box, and for any required wiring harnesses and connectors.

**781-3.1.11 Sign Controller Communication Interface:** Ensure that the sign controller includes two separate EIA-232 serial interfaces inside the sign housing for communication with the TMC or a laptop computer, and one Ethernet 10/100 Base TX *8P8C* port ~~that meets the Category 5 requirements detailed in this section~~. Ensure that EIA-232 serial interfaces support the following:

Data Bits: 7 or 8 bits

Parity: Even, Odd, None, Mark, or Spare

Number Stop Bits: 1 or 2 bit

Ensure that all Category 5 unshielded twisted pair/shielded twisted pair network cables are compliant with the EIA/TIA-568-A standard.

Configure one EIA-232 serial interface to drive asynchronous modems for full duplex communication with the TMC over point-to-point dial-up lines or a multidrop fiber or copper network. Ensure that switching between dial-up*, Ethernet,* and multidrop operation~~s~~ does not require sign controller software or hardware modifications.

For dial-up operations, acquire and bear the charges of installing and connecting the dial-up telephone line. Provide modems to be retained by the Department at each location. Provide a user-selectable data transmission rate of up to 19.2 kbps for dial-up operations.

Configure the second EIA-232 serial port for local communication with a laptop computer.

Ensure that the sign controller can be managed remotely from a TMC or locally using a laptop computer. Ensure that the TMC or a laptop computer can be used to remotely reset the sign controller.

Ensure that the sign controller and its software will display s*ingle-page and multi-page*~~tatic, alternating, and double-brush stroke~~ messages, with mixed fonts and spacing ~~for maximum legibility~~. Ensure that *message page times and text flashing rates are programmable* ~~the alternating frequency of the messages will vary~~ between 0.5 and 5 seconds in 0.1-second increments.

Ensure that the ~~unit's software~~*sign system* will *log and* report errors and failures, including data transmission errors, receipt of invalid data, communication failure recoveries, alternating current power failures, power recoveries, pixel status reads, fan and filter airflow status, temperature status, power supply status, and information on the operational status of the temperature, photocell, airflow, humidity, and LED power supply sensors. Ensure that airflow and humidity sensor information is reported using the objects from the dmsClimateCtrlStatusTable of the NTCIP 1203 V2 standard.

**781-3.1.12 Message and Status Monitoring:** Ensure that the ~~DMS~~*sign* provides two modes of operation: (1) master operation, where the TMC *commands and controls the sign and* determines the appropriate message or test pattern; and (2) local operation, where the sign controller or a laptop computer *commands and controls the sign and* determines the appropriate message or test pattern.

Keep electronic components away from the access door to protect them from the elements. Ensure that the walk-in housing containing the local control panel has switches that perform the following functions:

1. Control Selection – Ensure that the local/remote switch on the local control panel works in parallel with the local/remote switch located in the ground control box. Provide a LED indicator near the local/remote switch to indicate when either switch has selected the local mode. The operating mode is determined by the position of the mode switch on the local control panel. If the local control panel's switch is set to local, the operating mode is local. Otherwise, the operating mode is master.

2. Message Selection – Ensure that the sign controller's keypad may be used to select a blank message or any one of the messages stored in the sign controller's nonvolatile memory when the control mode is set to local.

3. Message Implementation – Ensure that the sign controller can activate the selected message.

Ensure that the sign controller transmits a return message to the TMC whenever it receives a valid status request. Ensure that return messages contain an Internet Protocol (IP) address for the sign controller, the actual message that is visibly displayed on the sign, the displayed message's transmission origin (i.e., the TMC, laptop computer, manual entry, etc.), ~~the Department master~~*remote* or local control ~~panel switch position~~*status*, error and failure reports, temperature readings, access ~~door~~ alarm*s*, power supply voltage levels, *line voltage,* and ~~the~~ UPS status.

In the event of a ~~power or~~ sign controller failure, ensure that the sign controller blanks any message displayed. *Ensure that the sign can be programmed to display a user-defined message, including a blank page, in the event of power loss.*

~~Ensure that the sign controller provides a minimum library of 50 messages complying with the range deviances for objects provided in Table 1.~~

Ensure that message additions, deletions, and sign controller changes may be made from either the remote TMC or a local laptop computer. Ensure that each font may be customized, and modifications to a font may be downloaded to the sign controller from the TMC or a laptop computer at any time without any software or hardware modifications. Ensure the sign is capable of displaying a different font and character spacing on each line.

Ensure that *messages can be activated with a run-time duration specified. Ensure that the sign can be programmed to display a user-defined message, including a blank page, once the run-time duration of another message*~~the TMC sets the sign to neutral (either a blank display or displaying a predefined default message) when a message's display time~~ has expired. Ensure that there is no perceivable flicker or ghosting of the pixels during sign erasure and writing periods.

Ensure that in the event of an AC power loss all nonvolatile memory is retained for a minimum of 30 calendar days. Ensure that the sign controller monitors the messages downloaded from the TMC or laptop computer to make sure that the message will fit in the display area of the sign. Ensure that the sign controller's internal time clock provides for message *deactivation* ~~s to be taken down~~ at the correct time, even in the event of a communication loss. Ensure that the sign controller maintains its internal clock during power outages and *automatically* displays the proper message when power is restored within 255 minutes. *Ensure that the sign can also be programmed to automatically blank the display following a power outage longer than* ~~If electric power is restored to the sign after~~ 255 minutes~~, no message will be displayed~~.

***781-3.2 Dynamic Message Sign with 12-inch Character Display (12" DMS):*** *Furnish and install a 12" DMS in accordance with the details specified in the Contract Documents.* ***781-3.2.1 General:*** *Ensure that all exposed material is corrosion resistant. Ensure that the electronic equipment associated with the sign remains secure from damage and protected from moisture, dust, dirt, and corrosion.*

*Ensure that ambient magnetic or electromagnetic fields, including those created by any system components, have no negative effects on system performance. Ensure that the system does not conduct or radiate signals that interfere with other electrical or electronic equipment including, but not limited to, other control systems and data processing, audio, radio, and industrial equipment.*

*Ensure that the sign housing complies with the fatigue resistance requirements of the fifth ~~fourth~~ edition ~~(2001)~~ AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals with current addendums. Design and construct the sign for continuous usage of at least 20 years and the sign structure for a 50-year design life. Ensure that equipment and structures are designed to withstand the wind loads defined in the FDOT Structures Manual without deformation or damage.*

*Ensure that the sign is fabricated, welded, and inspected in accordance with the requirements of the current ANSI/AWS Structural Welding Code-Aluminum. Ensure that all identification markings on the sign and its components, including but not limited to panels, terminal blocks, and printed circuit boards, are silk-screened and sealed or otherwise indelible. Ensure that the equipment design allows access and maintenance without special tools. Ensure that all component parts are accessible and available for inspection and maintenance for the duration of the system design life. Provide labeled test points for checking essential voltages. Ensure that all external connections are terminated using connectors. Key the connectors to preclude improper hookups. Provide a clear removable cover measuring a minimum of 0.125 inch thick to cover all exposed power terminals. Ensure that the covers do not interfere with sign functions or maintenance operations.*

***781-3.2.2 Sign Housing:*** *Ensure that the non-display external skin of the sign housing is constructed of aluminum alloy 5052 H32 that is a minimum of 0.090 inch thick. Ensure that the sign housing design and appearance is approved by the Engineer. If cable attachments are used in the sign housing, the cables shall be securely clamped using a method approved by the Engineer.*

*Ensure housing exterior is attached to the structural framework using a method approved by the Engineer. Ensure the housing bevel of the housing face is not greater than 1 foot on any side. Ensure housing provides an environmental seal for internal components with a minimum rating of IP54. Ensure all openings in housing (such as vents and drain holes) are safeguarded against the entrance of insects and animals.*

*Ensure LED display module(s) are mounted such that the legible viewing area is optimized.*

*Ensure all assembly hardware is in accordance with sections 603-2.4 and 603-2.5.*

*Ensure housing includes a method of hoisting to allow for proper mounting of device via use of standard construction equipment. Ensure the sign remains*

*level when hoisted. Ensure hoisting design prevents damage when device is shipped, handled, and installed.*

***781-3.2.2.1 Interior Structure:*** *Ensure that framing structural members are constructed of aluminum alloy (6061 T6 or 6063 T5) a minimum of 0.1875 inch thick.*

***781-3.2.2.2 Housing Face:*** *Ensure that housing face consists of internal structural members, external fascia panels, and lens panel assemblies. Do not allow exposed fasteners on the housing face.*

***781-3.2.2.2.1 Internal Structural Members:*** *Ensure that internal structural members are constructed of extruded aluminum. Ensure that the internal structural members retain the display modules in a manner that facilitates the easy and rapid removal of each display module without disturbing adjacent display modules.*

***781-3.2.2.2.2 External Fascia Panels:*** *Ensure that external fascia panels are constructed using aluminum. Ensure fascia panels are sealed to prevent intrusion of water, moisture, dust, dirt, and other contaminants into the sign interior. Finish each fascia panel with a matte black coating system that meets or exceeds American Architectural Manufacturers Association (AAMA) Specification No. 2605.*

***781-3.2.2.2.3 Lens Panel Assembly:*** *Provide lens panel assemblies that are modular in design, removable, and interchangeable without misalignment of the lens panel and the LED pixels. Ensure that lens panels include a mask constructed of 0.080 inch minimum thickness aluminum with a matte black coating that meets or exceeds AAMA Specification No. 2605 with a minimum thickness of 0.04 inch. Ensure that the mask is perforated to provide an aperture for each pixel on the display module. Ensure that the apertures are uniform, centered over each pixel, and as small as possible without blocking the LED output at the required viewing angle.*

*Ensure the lens panel assembly consists of LEDs, other internal electronics, an aluminum mask, and an environmental shielding layer coating to protect and seal the LEDs and other internal electronics. The coating shall be a minimum 90% ultraviolet (UV) opaque.*

***781-3.2.2.3 Sign Housing Surface Finish:*** *Ensure that all sign face surfaces are finished with a matte black FP-based coating system that meets or exceeds AAMA Specification No. 2605. Provide certification that the sign face parts are coated with the prescribed thickness. Ensure all other exterior and all interior housing surfaces are a natural aluminum mill finish. No interior painted surfaces are allowed.*

***781-3.2.2.4 Sign Housing Access:*** *Provide unobstructed front or rear access that allows servicing of internal components. Ensure access does not require specialized tools or excessive force.*

***781-3.2.2.5 Sign Housing Ventilation System:*** *If a ventilation system is required, ensure that it distributes air over all LEDs, power supplies, and communication devices inside the sign housing. Ensure that air circulation is evenly distributed within the housing. Submit ventilation system design calculations to the Engineer for approval.*

*Ensure that air drawn into the sign is filtered upon entry. Ensure that filters remove airborne particles measuring 500 microns in diameter and larger.*

*Ensure that the ventilation system is automatically tested once each day, and that it may be tested on command from remote and local control access locations. Ensure that the sign controller will send an error message to the designated monitoring personnel when a failure occurs. Ensure that the sign is capable of operating without any decrease in performance over an ambient operating temperature range of -29° to 165°F as per NEMA TS 4, Subsection 2.1.5.1, with a maximum relative humidity of 100%.*

*Ensure that any ventilation system has a fail-safe that includes a snap disk thermostat that is independent of the sign controller. Preset the thermostat at 130°F. If the sign housing's interior reaches 130°F, the thermostat will override the normal ventilation system, bypassing the sign controller and turning on all sign ventilation fans. The fans will remain under the control of the thermostat until the internal sign housing temperature falls to 115°F, at which time the fail-safe subsystem will return control of the ventilation system to the sign controller. Ensure that any ventilation system fans possess a 100,000-hour L10 life rating.*

***781-3.2.2.6 Sign Housing Temperature Sensor:*** *Ensure that the sign controller continuously measures and monitors the temperature sensors. Ensure that the sign can be programmed to blank when a user-defined critical temperature is exceeded. Ensure that the sign will report such events when polled. Ensure that the user-selectable, critical temperature may be changed by remote and local control access. Ensure that remote and local computers can read all temperature measurements from the sign controller. When the sign reaches a temperature that is 2° F lower than the critical high temperature, ensure that the sign controller will decrease the LED intensity to half its normal brightness.*

***781-3.2.2.7 Sign Housing Humidity Sensor:*** *Ensure the sign includes a humidity sensor that detects from 0 to 100% relative humidity in 1% or smaller increments. Ensure that the sensor will operate and survive in 0 to 100% relative humidity, and has an accuracy that is better than ±5% relative humidity. A humidistat is not acceptable.*

***781-3.2.2.8 Photoelectric Sensor Devices:*** *Ensure the sign electronics monitor ambient light using a minimum of three photocells. Ensure that the photocells are placed so they measure light levels on the front and rear of the sign, and ambient light conditions at the sign location. Ensure that the devices provide accurate ambient light condition information to the sign controller for automatic light intensity adjustment. Ensure that the automatic adjustment of the LED driving waveform duty cycle occurs in small enough increments that the sign's brightness changes smoothly, with no perceivable brightness change between adjacent levels. Ensure that stray headlights shining on the photoelectric sensor at night do not cause LED brightness changes.*

*Supply the sign with a brightness-versus-ambient light matrix table with algorithms and/or other means of calculation that enables the sign to automatically adjust LED output according to ambient light level. Ensure the sign controller monitors the photocell circuits in the sign and correlates the readings with the brightness table to convert the measured light intensity into the desired pixel brightness. Ensure that the brightness table has a minimum of 255 levels. Ensure that the brightness table in each individual sign controller is adjustable from remote or local control access,*

*and can be customized according to each installation site's requirements. Ensure that the sign controller automatically controls the pixel brightness to compensate for differences in ambient light levels, such as the differences in day and night. In addition to the automatic mode, ensure that the brightness may be set from 1% to 99% in 1% increments manually from the front panel of the sign controller and remotely from the TMC.*

*Ensure that the brightness and color of each pixel is uniform over the sign's entire face within a 30 degree viewing angle from 100 to 600 feet in all lighting conditions. Non-uniformity of brightness or color over the sign's face shall be cause for rejection of the sign.*

***781-3.2.3 Display Modules:** Provide display modules manufactured by one source and fully interchangeable throughout the manufacturer's sign system(s). Ensure that removal of a single display module does not impact the operation of other display modules. Ensure that removal or replacement of a complete display module or LED board can be accomplished without the use of any tools.*

*Ensure display modules contain solid-state electronics needed to control pixel data and read pixel status.*

***781-3.2.3.1 Module Arrangement and Character Size:** Assemble display modules to form a full matrix display as shown in the plans. Ensure that the display is capable of providing a minimum character size of 12-inches when using 5-pixel by 7-pixel characters.*

***781-3.2.3.2 LED and Pixel Specifications:** Ensure that the 12" DMS utilizes amber, three-quarter diode LED lamps with a minimum viewing angle of 30 degrees and a peak wavelength of 590 nanometers. Ensure that the LED peak wavelength output varies no more than ±2 nanometers. Ensure that the LED pixel cone of vision is a minimum of 30 degrees (centered on the optical axis, or zero point, of the pixel). The cone perimeter is defined by the point where light output intensity is 50% of the intensity measured at the zero point of the pixel.*

*Ensure that each pixel has a diameter of 1.0 inches, ±10%, and that the LEDs in each pixel are clustered to maximize long-range visibility. Ensure that all pixels in all signs in a project, including operational support supplies, have equal color and on-axis intensity. Ensure that each pixel's on-axis intensity is a minimum of 40 candelas when operating at 100% intensity. Measure the brightness of each LED in accordance with the International Commission on Illumination's (CIE) requirements as detailed in Test Method A of the CIE 127 (1997) standard. Provide the LED brightness and color bins that are used in each pixel to the Engineer for approval. Provide a letter of certification from the LED manufacturer that demonstrates testing and binning according to the CIE 127 (1997) standard.*

*Ensure each pixel contains two interlaced circular strings of LEDs powered from a regulated power source providing a maximum of 25 volts of direct current ($V_{DC}$). Ensure that LED power current is maintained at 25 milliamperes, ±2 milliamperes. Ensure that LED failure in one string within a pixel does not affect the operation of any other string or pixel. Do not exceed 1.5 watts per pixel for power drawn from a direct current (DC) supply, including the driving circuitry.*

*Provide a pixel test as a form of status feedback to the TMC from the local sign controller. Ensure that the operational status of each pixel in the sign can be automatically tested once a day. Ensure the operational status may also be tested*

*when the TMC or a laptop computer prompts a pixel test either remotely or on-site. Ensure that a log file can be created containing a list of defective pixels as transmitted to the TMC or a laptop computer. Ensure that the log file includes the pixel status, module number, column number, and pixel number. Ensure that the pixel status test determines the functional status of the pixel as stuck-on or stuck-off and does not affect the displayed message for more than half a second.*

*Ensure that LEDs are individually mounted directly on a PCB, and are individually removable and replaceable using conventional electronic repair methods.*

***781-3.2.3.3 Optical, Electrical, and Mechanical Specifications for Display Modules:*** *Ensure that each display module contains connectors for power, controls, and data; contains display module control electronics and memory elements; and provides the signals to switch the LED pixels.*

*Ensure the display modules are rectangular and have an identical vertical and horizontal center-to-center distance (i.e., pitch) between adjacent pixels ranging from 1.71 inches to 1.82 inches. Ensure that the separation between the last column of one display module and the first column of the next module is equal to the horizontal distance between the columns of a single display module.*

*Ensure that the LED circuit board is a NEMA FR4-rated, single 0.062-inch, black PCB. Ensure that alternate LED board configurations are submitted to and pre-approved by the Engineer prior to installation. Ensure that PCBs enable components to be removed and replaced without damage to boards, traces, or tracks. Ensure that the intercomponent wiring is a copper-clad track having a minimum weight of 2 ounces per square foot with an adequate cross section for carrying circuit current. Ensure that no PCB has more than two PCB jumper wires present. Finish all PCBs with a solder mask and a component identifying silk screen.*

*Provide all PCBs, except for the LED motherboard and power supply PCBs, with a complete and conformal coating of silicone or acrylic resin with a minimum thickness of 0.01 inch. Provide the LED motherboards with a complete conformal coating of silicone or acrylic resin with a minimum thickness of 0.01 inch, except for the pixels on the front of the PCB. Meet the material requirements of MIL-I-46058C Military Standard, United States Department of Defense (USDOD).*

*Mount all LEDs so that the mechanical axis of the LED is ±1 degree to the sign's face to ensure uniformity of brightness over the sign's face. Ensure that LEDs are secured perpendicular to the display module within 0.5 degree and may be easily removed from the display module PCB without tools. Ensure that any devices used to secure LEDs do not block air flow to the LED leads or block the LED light output at the required viewing angle. Ensure that all components on the LED side of PCBs are black.*

*Ensure that the voltage to the LED modules and their associated electronics does not exceed 25 $V_{DC}$. Ensure that there are a minimum of two, and a maximum of four, power supplies that are wired in a parallel configuration for redundancy. Ensure that multiple power supplies are used to provide power to each display module. Ensure the voltage measured at the display modules does not vary more than 50 millivolts over all the display modules in the sign with 17 pixels on at 100% intensity in each display module. Ensure that if one supply completely fails, the sign shall*

*still be supplied with enough power to run 40% of all pixels at a 100% duty cycle with an ambient operating temperature of 165° F. Ensure that the supplies have a current sharing capability that allows them to provide equal amounts of current to their portion of the LED display.*

*Ensure that the sign controller continuously measures and monitors all LED module power supply voltages and provides the voltage readings to the TMC or a laptop computer on command. Ensure that an error message will be sent to the TMC or a laptop computer when it polls the sign controller if voltages measured are outside nominal values.*

*Ensure that LEDs are protected from external environmental conditions, including moisture, snow, ice, wind, dust, dirt, and UV rays. Do not use hoods, louvers, cylinders or visors that could impede the free flow of air over any surface of each individual LED. Do not use epoxy to encapsulate the LEDs.*

***781-3.2.4 Character Displays:*** *Ensure that the signs are capable of displaying American Standard Code for Information Interchange (ASCII) characters 32 through 126, including all uppercase and lowercase letters and digits 0 through 9, at any location in the message line.*

*Ensure that the uppercase alphanumeric characters are displayed over the complete height of the matrix. Submit a list of the character fonts to the Engineer for approval.*

*Characters must be legible under all light conditions at a distance ranging from 100 to 600 feet within the 30-degree cone of vision centered on the pixel's optical axis. Ensure that the operator is able to display compressed, expanded, or double-stroke character fonts, and to change the default spacing between characters. Ensure that the spacing options include 1-, 2-, or 3-pixel columns between the characters. Ensure the system is loaded with a default font in accordance with the Standard Font set described in NEMA TS4-2005 (section 5.6). Ensure the system allows the assignment of font access privileges. Ensure that the sign controller is capable of a self-updating time and/or date display on the sign.*

*Ensure that the sign controller allows a moving arrow to be displayed on one line with a standard text message on the other lines. Ensure that the moving arrows may be shown moving from the left or right, and starting from one end or in the middle of the sign and continuing to the end of the sign.*

***781-3.2.5 Main Power Supply and Energy Distribution Specifications:*** *Provide a nominal single-phase power line voltage of 120/240 $V_{AC}$ protected by a two-pole (i.e., common trip) main circuit breaker sized as required for the sign and its controller. Ensure that the system operates within a voltage range of 97 to 135 $V_{AC}$ as specified in NEMA TS 4, Subsection 2.1.3.1.*

*Ensure that all power inside the sign housing is supplied by 120 $V_{AC}$ independently protected by a thermomagnetic circuit breaker at the sign's service entry point. Locate all 120 $V_{AC}$ wiring in conduit, pull boxes, raceways, or control cabinets as required by the NEC. Ensure that no 120 $V_{AC}$ wiring is exposed inside or outside of the sign housing. Do not use the sign housing as a wiring raceway or control cabinet.*

*Ensure that the sign and its controller have an operating frequency of 60 hertz (Hz), ±3.0Hz, as stated in NEMA TS 4, Subsection 2.1.3.2. Ensure that the*

*drop in the unit's voltage between no-load and full-load during normal operations does not exceed 10% of the nominal voltage. Provide power protection through the use of a thermomagnetic circuit breaker connected to a 5-milliampere GFI device that protects all service outlets. Provide a 100-amp 120/240 $V_{AC}$ two-pole load center with a 20-circuit capability. Provide separate circuit breakers for each sign circuit.*

*Provide Type XHHW power cables sized as required by the NEC for acceptable voltage drops while supplying alternating current to the sign. Ensure that the sign power consumption does not exceed 3,000 VA under any circumstance, including operation of fans and heaters (if provided within the sign), sign controllers and communication equipment, and all pixels illuminated at 100% brightness.*

*Provide protection devices such as surge suppressors and lightning arrestors installed or incorporated in the sign system by the manufacturer to guard against lightning, transient voltage surges, and induced current. Ensure that the protection devices meet or exceed the device protection requirements as contained in Section 785-2. Use protection devices on all electric power and data communication connections.*

*Ensure that the DC and AC voltage ratings and dissipation factors of capacitors used in the sign system exceed the worst-case design parameters of the circuitry by 50%. Ensure that capacitors that are not surface mount components are mechanically supported by a clamp or fastener that is resistant to cracking, peeling, and discoloration.*

*Ensure that resistors used in the sign are within 5% of the tolerance of the specified temperature range and, when operated in excess of 50% of its power rating, have an adequate heat sink.*

*Ensure all transistors, integrated circuits, and diodes are a standard type, listed by the EIA, and clearly identifiable.*

***781-3.2.6 Uninterruptible Power Supply:** Provide each sign with an uninterruptible power supply (UPS) capable of maintaining and continuing the operation of the sign and its related communication device for a minimum of two hours. Provide sealed AGM type batteries that are maintenance free.*

***781-3.2.7 Operational Support Supplies:** Furnish the operational support supplies listed in the table below. Promptly replace any of the supplies used to perform a warranty repair.*

*For every group of 10 or fewer 12" DMS signs provided or required, provide 1 set of supplies as follows:*

| | |
|---|---|
| *1 each* | *Sign Controller* |
| *5 each* | *LED Display Modules* |
| *1 each* | *Uninterruptible Power Supplies* |
| *1 each* | *System Interface Circuit* |
| *1 each* | *Cable for connecting interface circuits to daughter boards (if applicable)* |
| *1 each* | *Display Module Cables* |
| *2 each* | *Surge Suppression Sets* |
| *1 each* | *Fan Assembly* |
| *1 each* | *Time Relay for Fan Control* |

| | |
|---|---|
| *10 each* | *Every Small Fuse (< 10 amp)* |
| *2 each* | *Every Large Fuse (> 10 amp)* |
| *1 each* | *Sensor for each type of sensor* |

*The Engineer will review and approve the operational support supplies.*

***781-3.2.8 Sign Controller:*** *Ensure that the sign is provided with a sign controller that includes operational firmware stored in nonvolatile memory. Program the controller to receive sign control commands, transmit responses (as requested), and to control sign operation and message displays both remotely and on site to and from designated users. Ensure that sign controller functions include error logging and reporting, and providing the operational status of the sensors including temperature, photocell, airflow, and humidity and LED power supply sensors.*

*Ensure that the sign controller will read the internal temperature sensors, the external ambient temperature sensors, and the humidity sensors and use the readings in an algorithm that turns on heat tape and/or fans when conditions warrant preventing frost on the face of the sign and condensation on the display modules and other electronic circuitry.*

*Ensure that the sign controller receives and sends messages by way of an Ethernet network and that the failure of any sign does not affect the operation of any other sign in the system.*

*Ensure that, at a minimum, the sign controller provides for local control and programming of the sign, including power on/off, communications, and sign diagnostics and error status.*

*Ensure that the controller provides power-up and automatic restart capabilities with automatic sign blanking when recovering from a power-off condition. Ensure that the sign can be configured to either display a stored message or blank upon recovery from power loss and upon recovery from system resets. Utilize a hardware watchdog circuit to provide automatic recovery from critical errors and automatic shutdown in the event of critical hardware failure.*

*Mount the sign controller within the sign housing. Ensure that there is a ground level access point at the sign location that allows the sign to be programmed and controlled locally using a laptop computer.*

***781-3.2.9 Display System Hardware:*** *Ensure the sign utilizes a system data interface circuit for communication between the sign controller and display modules. Ensure that the following components reside inside the sign housing: sign controller, display system interface circuits, display modules, power supplies, local and remote control switches, LED indicators, Electronic Industries Alliance (EIA)-232 null modem cables (minimum of 4 feet long for connecting laptop computer to sign controller), and transient voltage surge suppressors.*

***781-3.2.10 Control Cabinet Specifications:*** *Provide a control cabinet that meets the requirements of Section 785-4.*

*Equip the ground control cabinet with the assemblies and components, as shown in the plans: power indicator, surge suppression on both sides of all electronics, communication interface devices, connection for a laptop computer for*

*local control and programming, cables a minimum of 4 feet long to connect laptop computers, a UPS system, a workspace for a laptop computer, and duplex outlets.*

*Provide for all telephone, data, control, power, and confirmation connections between the sign and ground control box, and for any required wiring harnesses and connectors.*

***781-3.2.11 Sign Controller Communication Interface:*** *Ensure that the sign controller includes two separate EIA-232 serial interfaces inside the sign housing for communication with the TMC or a laptop computer, and one Ethernet 10/100 Base TX 8P8C port. Ensure that EIA-232 serial interfaces support the following:*

*Data Bits: 7 or 8 bits*
*Parity: Even, Odd, None, Mark, or Spare*
*Number Stop Bits: 1 or 2 bit*

*Ensure that all Category 5 unshielded twisted pair/shielded twisted pair network cables are compliant with the EIA/TIA-568-A standard.*

*Configure one EIA-232 serial interface to drive asynchronous modems for full duplex communication with the TMC over point-to-point dial-up lines or a multidrop fiber or copper network. Ensure that switching between dial-up, Ethernet, and multidrop operation does not require sign controller software or hardware modifications.*

*For dial-up operations, acquire and bear the charges of installing and connecting the dial-up telephone line. Provide modems to be retained by the Department at each location. Provide user selectable data transmission rates of up to 56 kbps for dial-up operations.*

*Configure the second EIA-232 serial port for local communication with a laptop computer.*

*Ensure that the sign controller can be managed remotely from a TMC or locally using a laptop computer. Ensure that the TMC or a laptop computer can be used to remotely reset the sign controller.*

*Ensure that the sign controller and its software will display single-page and multi-page messages with mixed fonts and spacing. Ensure that message page times and text flashing rates are programmable between 0.5 and 5 seconds in 0.1-second increments.*

*Ensure that the sign system will log and report errors and failures, including data transmission errors, receipt of invalid data, communication failure recoveries, alternating current power failures, power recoveries, pixel status reads, fan and filter airflow status, temperature status, power supply status, and information on the operational status of the temperature, photocell, airflow, humidity, and LED power supply sensors. Ensure that airflow and humidity sensor information is reported using the objects from the dmsClimateCtrlStatusTable of the NTCIP 1203 V2 standard.*

***781-3.2.12 Message and Status Monitoring:*** *Ensure that the 12” DMS provides two modes of operation: (1) master operation, where the TMC commands and controls the sign and determines the appropriate message or test pattern; and (2) local operation, where the sign controller or a laptop computer commands and controls the sign and determines the appropriate message or test pattern.*

*Ensure that the sign can perform the following functions:*

*1. Control Selection – Ensure that local or remote sign control can be selected. Ensure that there is a visual indicator on the controller that identifies whether the sign is under local or remote control. Ensure that the sign*

*responds to remote control by default. If the sign includes a physical local/remote mode switch, the operating mode must be determined by the position of the mode switch on the local control panel. If the local control panel's switch is set to local, the operating mode is local. Otherwise, the operating mode is master.*

*2. Message Selection – Ensure that the sign controller can select a blank message or any one of the messages stored in the sign controller's nonvolatile memory when the control mode is set to local.*

*3. Message Implementation – Ensure that the sign controller can activate the selected message.*

*Ensure that the sign controller transmits a return message to the TMC whenever it receives a valid status request. Ensure that return messages contain an Internet Protocol (IP) address for the sign controller, the actual message that is visibly displayed on the sign, the displayed message's transmission origin (i.e., the TMC, laptop computer, manual entry, etc.), remote or local control status, error and failure reports, temperature readings, access alarms, power supply voltage levels, line voltage, and UPS status.*

*In the event of a sign controller failure, ensure that the sign controller blanks any message displayed. Ensure that the sign can be programmed to display a user-defined message, including a blank page, in the event of power loss.*

*Ensure that message additions, deletions, and sign controller changes may be made from either the remote TMC or a local laptop computer. Ensure that each font may be customized, and modifications to a font may be downloaded to the sign controller from the TMC or a laptop computer at any time without any software or hardware modifications. Ensure the sign is capable of displaying a different font and character spacing on each line.*

*Ensure that messages can be activated with a run-time duration specified. Ensure that the sign can be programmed to display a user-defined message, including a blank page, once the run-time duration of another message has expired. Ensure that there is no perceivable flicker or ghosting of the pixels during sign erasure and writing periods.*

*Ensure that in the event of an AC power loss all nonvolatile memory is retained for a minimum of 30 calendar days. Ensure that the sign controller monitors the messages downloaded from the TMC or laptop computer to make sure that the message will fit in the display area of the sign. Ensure that the sign controller's internal time clock provides for message deactivation at the correct time, even in the event of a communication loss. Ensure that the sign controller maintains its internal clock during power outages and automatically displays the proper message when power is restored within 255 minutes. Ensure that the sign can also be programmed to automatically blank the display following a power outage longer than 255 minutes.*

**781-3.~~1.1~~3 TMC Communication Specifications *for all DMS*:** Ensure that the sign controller is addressable by the TMC through the Ethernet communication network using software that complies with the NTCIP 1101 base standard (formerly the NEMA TS 3.2 -1996 standard), including all amendments as published at the time ~~the Request for Proposals is released~~*of contract letting*, and the NTCIP Simple Transportation Management Framework, and conforms to Compliance Level 1. Ensure that the software implements all mandatory objects as defined in the FDOT standard Global MIB ~~v01c~~ in

Appendix A, all mandatory objects as defined in the FDOT-standard DMS MIB ~~v01c~~ in Appendix B, and all mandatory objects as defined in the FDOT-specific DMS MIB ~~v01c~~ in Appendix C *as published online at http://www.dot.state.fl.us/trafficoperations/APL/fdot_dms_info.shtm at the time of contract letting*. Ensure that the ~~DMS~~*sign* complies with the NTCIP 1201 v01, 1203 v01, 2101 v01.19, 2103 v01.13, 2201 v01.14, 2202 v01.05, and 2301 v01.08 standards. *Ensure that compliance with FDOT MIB requirements takes precedence within NTCIP implementations.* Ensure that any additional objects implemented by the software do not interfere with the standard operation of any mandatory objects.

Ensure that each ~~DMS~~*sign* provides full, standardized range support for all objects required by these specifications unless otherwise detailed in the plans. The standardized range is defined by a size, range or enumerated listing indicated in the object's syntax field and/or through descriptive text in the relevant standard object description field. Ensure that the ~~DMS~~*sign* maximum response time for any object or group of objects is 200 milliseconds unless otherwise indicated in the plans, or unless approved by the FDOT Traffic Engineering Research Laboratory (TERL). Deviances from the full ranges for objects are detailed in Table 1.

| Table 1 – Range Deviances for Objects | |
|---|---|
| Object | Minimum Project Requirements |
| FDOT Global MIB v01c | |
| Maximum Event Log Configurations | 50 |
| Event Configuration Mode | 2, 3, and 4 |
| Maximum Event Log Size | 200 |
| Maximum Event Classes | 7 |
| Maximum Group Address | 1 |
| FDOT DMS MIB v01c | |
| Number of Fonts | 4 |
| Maximum Font Characters | 255 |
| Default Background Color | 0 |
| Default Foreground Color | ~~2, 7, 8, or~~ 9 |
| Default Justification Line | 2, 3, 4 |
| Default Justification Page | 2, 3, 4 |
| DMS – Number of Permanent Messages | 0 |
| DMS – Maximum Changeable Messages | 50 |
| DMS – Maximum Volatile Messages | 0 |
| Nonvolatile Memory | 5 KB |
| DMS – Control Mode | 2, 3, 4, and 5 |
| Number of Action Table Entries | 15 |
| Number of Brightness Levels | 255 |

Ensure that the software implements the tags (opening and closing where defined) of MULTI as detailed in Table 2 and as defined in the NTCIP 1203 standard.

| **Table 2 – NTCIP 1203 Standard Software Tags** * |
|---|

| Opening Tag | Closing Tag | Explanation |
|---|---|---|
| cbx | | Color – Background – The background color for a message. |
| cfx | | Color – Foreground – The foreground color for a message. |
| fx,y | | Field – The information to embed within a message that is based on data from some device, such as a clock, calendar, temperature sensor, detector, etc.<br>The following field tag values (IDs) are REQUIRED to be supported:<br>1 – the time in a 12-hour format;<br>2 – the time in a 24-hour format;<br>4 – the ambient temperature in degrees Fahrenheit;<br>7 – the day of the week;<br>8 – the date of the month;<br>9 – the month of the year;<br>10 – the year in two digits; and<br>11 – the year in four digits. |
| fltxoy | /fl | Flash – Activate flashing of the text; define the flash-on and flash-off times; and the flash order (i.e., on/off or off/on). |
| fox | | Font – Select a font number (as specified in the font table) for the message display. |
| jlx | | Justification – Line – Specify line justification: left, center, right, or full. However, full justification is not required. |
| jpx | | Justification – Page –Specify page justification: top, middle, or bottom. |
| mvtdw,s,r,text | | Moving – Text – Specify the parameters of a horizontal moving (scrolling) text. |
| nlx | | New – Line – Specify the start of a new line. |
| np | | New – Page – Specify the start of a new page. |
| ptxoy | | Page – Time – Specify the page times (t = on, o = off). |
| scx | /sc | Spacing – Character – Specify the spacing between characters. |
| * The letters “x” and “y” are character placeholders, usually for numbers, that specify the tag parameter(s). See the NTCIP 1203 standard and its amendments for further definitions. | | |

Provide each sign controller with error detection and reporting features that will be used to guard against incomplete or inaccurate transmissions including cyclic redundancy checking of all data received from the TMC, with positive acknowledgment for all valid transmissions; status monitoring for communication line malfunctions or breakages; and content validation for all transmissions received for logic or data errors.

Provide communication line circuits that are point-to-point or multipoint, and that provide full duplex asynchronous data transmissions at the rate *shown in the contract documents or* directed by the Engineer.

Assign each sign controller a unique *address* ~~*within the network schema* address in the circuit that the sign is connected to~~. Where applicable, encode all data transmitted between the TMC and the sign controller using 1 start bit, 8 data bits, and 1 stop bit.

~~———~~**781-3.*4*~~1.1~~4 Electronic Components:** Ensure that all electronic components, with the exception of PCBs, are commercially available, easily accessible and replaceable, and individually removable using conventional electronic repair methods.

Ensure that all workmanship complies with the ANSI International Policy Committee (IPC) requirements as defined in the ANSI/IPC-A-610B, ANSI/IPC-7711, and ANSI/IPC-7721 Standards.

~~———~~**781-3.~~1.1~~5 Mechanical Components:** Ensure that the ~~DMS~~*sign* is fabricated using only stainless steel external screws, nuts, and locking washers. Do not use self-tapping screws unless specifically approved by the Engineer. Ensure that all parts are fabricated from corrosion-resistant materials, such as plastic, stainless steel, aluminum, or brass. Ensure that construction materials are resistant to fungus growth and moisture deterioration. Ensure that all dissimilar metals are separated with an inert, dielectric material.

**781-3.2~~5~~*6* Sign Control Software:** Ensure that the ~~DMS~~*sign* is provided with computer software *from its manufacturer* that allows an operator to program, operate, exercise, diagnose, and read current status of all sign features and functions using a laptop computer. Ensure that sign control software provides a graphical representation that visibly depicts the sign face and the current ON/OFF state of all pixels as well as allows messages to be created and displayed on the sign. Ensure that the laptop computer and sign can communicate when connected directly by an EIA-232 cable *and via Ethernet*. Ensure that the laptop computer and ~~DMS~~*sign* can communicate across the ITS system's communication network using the NTCIP standards described in this document. Ensure that the software will allow communication between multiple users and multiple signs across the same communication network.

**781-3.3~~6~~*7* Sign Support Structure:** Meet the requirements of 700-2.4.

**781-3.4~~7~~*8* Installation Requirements:** Do not install the ~~DMS~~*sign* prior to the availability of electric power. Verify that *any*~~the~~ ventilation system *incorporated within the sign is operational* ~~operates in each DMS~~ within 72 hours *after* ~~of~~ sign *installation*~~mounting~~.

Set the sign housing's vertical angular alignment as shown in the plans~~ or as directed by the Engineer~~. Ensure that lifting eyebolts are removed and any remaining holes in the top surface of the ~~DMS~~*sign* are sealed to prevent water entry after installation.

Load the initial message libraries on both the *sign control software*~~TMC~~ and the sign controller. The Engineer will furnish the messages to be placed in these libraries.

**781-3.5~~8~~*9* Documentation:** Provide documentation as noted below, reflecting the as-built conditions necessary to facilitate the operation, maintenance, modification, and expansion of the DMS system or any of its individual components. Manufacturer-supplied documentation that covers the intent of these specifications may be used, subject to the approval of the Engineer.

Provide the Engineer with two paper copies and one electronic copy of all documentation. Print the paper copies on 8 1/2-by-11-inch paper and place in three-ring binders. Format the electronic copy in portable document format and submit on CD-ROM. Ensure that electronic submittals are compatible with the Department's own

software and CADD programs at the time submittals are made. In addition, place one paper copy of an operations and maintenance manual and as-built drawings, wiring diagrams, and schematics at each DMS location. Ensure that the drawings are printed on 11-by-17-inch sheets and include structural member and attachment support details. Provide each of the following items in the operations and maintenance manual:

1. A general description of the equipment's basic use and function. Provide a general block diagram of the DMS equipment, including the nomenclature, physical and electrical characteristics, and the functions of any auxiliary devices utilized.

2. Sections describing the DMS using block diagrams and schematic drawings. Furnish layout drawings showing the location of all components, along with a complete components list. Use a logical development starting with a system block level and proceeding to a circuit analysis. Detail the circuit analysis whenever circuits are not normally found in standard textbooks. Fully describe the application of new theoretical concepts. Where the design allows operation in a number of different modes, provide an operational description of each mode.

3. The standard routine of operation for the DMS, from necessary preparations for placing the equipment into operation to securing the equipment after the beginning of operation. Include appropriate illustrations with the sequence of operations presented in tabular form wherever feasible. Provide a list of applicable test instruments, aids, and tools required in the performance of necessary measurements and techniques for each system component. Describe setup tests and calibration procedures.

4. Information required to maintain, diagnose, and repair the sign and its controller to the component level, including the manufacturer's recommended procedures for preventive maintenance performed weekly, monthly, quarterly, semi-annually, and annually, and any other required maintenance checks necessary to assure reliable equipment operation. Fully describe all adjustments and alignment procedures and provide descriptions of expected signals at all test points and outputs. List all requirements, including tolerances for all electrical, mechanical, and other applicable measurements and adjustments. Provide a repair and troubleshooting decision tree that describes each function, the tests of each function, and any process that defines faulty elements that require repair, replacement, or adjustment to restore operation of a malfunctioning sign or system element.

5. General instructions for the disassembly, overhaul, and reassembly of the DMS, including shop specifications and operating performance specifications.

6. Detailed instructions and specifications for maintenance that must be accomplished by specialized technicians and engineers in a modern electromechanical shop. Include instructions that describe special test setups, component fabrications, and the use of special tools, jigs, and test equipment.

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

8. A parts list containing all equipment within a group, and a list of all assemblies, subassemblies, and unit replacement parts. Arrange the list in alphanumerical order of the schematic reference symbols and shall give the associated description, manufacturer's name, and part number. Provide a table of contents or some

other appropriate grouping method for the purpose of identifying major components, assemblies, etc.

9. Complete and accurate schematic diagrams as required to supplement the text material and to allow the books to be self-contained technical information sources. Include part reference symbols, test voltages, waveforms, and other aids to understanding the circuit's functions on the diagrams.

Include drawings of conduit layouts, cable diagrams, wiring lists, control cabinet layouts, wiring diagrams, and schematics for all elements of the communication system in the final documentation. Include detailed drawings identifying the routing of all conductor pairs in the communication system by cable type, color code, and function. Upon completion of the installation, submit these plans, maps, drawings, and/or diagrams to reflect an as-built condition, incorporating all changes made during installation, such as in-pair identification and routing.

Provide software and documentation for the TMC software system and its components including, but not limited to all documentation concerning the sign controller communication protocol, including information needed to define the interface design, software codes, message definitions, and message sequences for DMS control and feedback; and one complete copy of the manufacturer's documentation for plug-in circuit cards used in the microcomputer chassis.

Provide documentation that reflects all field changes and software modifications and revisions prior to the power-on test period for the DMS. Modify the documentation with any final corrections or adjustments made during the test period. Submit the documentation to the Engineer within seven days of the successful completion of the operational testing.

**781-3.*10*~~6~~ Licensing:** Ensure that the manufacturer grants the Department a nonexclusive, unrestricted license that allows the Department to use, modify, and/or distribute any and all of the stated communication protocols, sign operating systems, drivers, and documentation.

**781-3.~~7~~*11* Technical Assistance:** Ensure that a manufacturer's representative is available (preferably on site) to assist the Contractor's technical personnel at each sign installation site for sign-to-sign structure installation, sign controller cabinet installation, and sign-to-controller cabling.

Do not proceed with the initial powering up of the sign(s) without the permission of the manufacturer's representative.

**781-3.*12*~~8~~ Testing:** Conduct performance testing of materials and equipment not previously tested and approved. If the technical data is not considered adequate for approval, samples may be requested for testing by the Engineer. The contract period will not be extended for time lost or delays caused by testing prior to the Engineer's final approval of any items.

Subject the equipment covered by these specifications to design approval tests (DATs) and factory demonstration tests (FDTs). The Engineer may accept certification by an independent testing laboratory in lieu of the DATs to verify that the tests have been previously completed satisfactorily. Arrange and conduct the tests in accordance with the testing specifications stated in this section. Unless otherwise specified, the Contractor is responsible for satisfying all inspection requirements prior to submission for the Engineer's inspection and acceptance.

The Engineer reserves the right to witness all DATs and FDTs. The tests on all or one type of equipment must be completed within five calendar days. The Contractor shall be financially responsible for testing each DMS.

Provide five copies of all design approvals, FDTs, stand-alone and subsystem test procedures, and data forms for the Engineer's approval at least 60 calendar days prior to the beginning of testing. Include in the test procedures the sequence in which the tests will be conducted. Obtain the Engineer's approval of the test procedures prior to testing the equipment.

Furnish data forms, certified and signed by the manufacturer, containing all of the data taken, and the quantitative results for all tests. Send one copy of the data forms to the Engineer.

Provide the test fixtures and test instruments for all the tests.

**781-3.8~~1~~*2*.1 Design Approval and Preshipment Factory Demonstration Testing:** Conduct DATs on one or more samples of each type of equipment, as approved by the Engineer, to determine whether the equipment design meets ~~the DMS specification's~~*project* requirements. Conduct the test in accordance with the approved test procedures as described in this section. All requirements listed ~~below~~ *herein* take precedence over the applicable NEMA TS 4 standard.

~~Notify the Engineer a minimum of 30 calendar days in advance of the time these tests are to be conducted.~~

**781-3.8~~1~~*2*.1.1 Temperature and Condensation:** Provide results of the ~~DMS and sign controller~~ FDTs to the Engineer or his representative prior to shipment ~~of any DMS equipment~~. Test requirements include the following:

1. Stabilize the equipment at -29°F. After temperature stabilization, operate the equipment without degradation for two hours.
2. Cause moisture to condense on the equipment by allowing it to warm to room temperature in an atmosphere having a relative humidity of at least 40% and satisfactorily operate the equipment for two hours while wet.
3. Stabilize the equipment at 165°F. After stabilization, satisfactorily operate the equipment for two hours without degradation or failure.

**781-3.8~~1~~*2*.1.2 Primary Power Variation:** The equipment shall meet the defined performance specifications when the nominal input voltage is 120 volts, ±11.5 volts. Operate the equipment at extreme limits for at least 15 minutes, successfully performing FDTs.

**781-3.8~~1~~*2*.1.3 Relative Humidity:** The equipment shall meet its performance specifications when subjected to an ambient operating temperature of 165°F and a relative humidity of 90%. Maintain the equipment at the above condition for 48 hours. At the conclusion of the 48 hour soak, the equipment shall meet FDT requirements within 30 minutes of beginning the test.

**781-3.8~~1~~*2*.1.4 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 required in Section 2.2.5 of the NEMA TS 4 standard.

**781-3.8~~1~~*2*.1.5 Water Spray Hose Test:** Test the fully assembled DMS by way of a directed water spray hose test. The test shall consist of a 10-minute

soaking of the DMS by way of two constant streams of water. The water spray shall be delivered by two hoses, 0.625 inch in diameter, with a water throughput of 6 gallons per minute at 45 pounds per square inch. One hose with a medium spray nozzle shall be directed at the sign face. The hose setup for the sign face shall be placed 15 feet from the sign face, be 12 feet in height, and be set at a 45-degree down angle. The second hose with a heavy spray nozzle shall be directed at the top of the sign cabinet in the form of heavy spray. This top hose setup shall be set at 10 feet directly above the sign cabinet pointing directly down on top of the cabinet. The water shall run continuously for 10 minutes. At the end of the test period, the interior of the sign shall be inspected for leaks, water/moisture contamination of the electronics, standing water in the base of the sign, and any other abnormal water/moisture issues. Note any leaks and have them permanently repaired. Retest until all leaks are stopped. Note all repairs on the as-built documentation.

**781-3.*12*~~8~~.2 Preshipment Factory Demonstration Testing:** Conduct FDTs on all units at a Contractor-provided facility. Notify the Engineer a minimum of 30 calendar days before the start of tests. Conduct all tests in accordance with the approved test procedure contained in this section. All equipment shall have passed the following individual tests.

**781-3.8*12*.2.1 Product Examination Test:** Examine each piece of equipment carefully to verify that the materials, design, construction, markings, and workmanship comply with the requirements of these specifications.

**781-3.*12*~~8~~.2.2 Continuity Test:** Check the wiring to determine conformance with the requirements of the appropriate paragraphs in these specifications.

**781-3.8*12*.2.3 Operational Test:** Operate each piece of equipment long enough to permit equipment temperature stabilization, and to check and record an adequate number of performance characteristics to ensure compliance with the requirements of these specifications.

Have factory personnel make necessary changes and repairs, making notations of the repairs on the as-built documentation. Retest ~~the DMS~~ to verify the proper operation of the ~~now~~ repaired components. Upon satisfactory completion of all pre-shipment testing, the Engineer will release the sign for shipment.

If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the Department and/or without an extension of the contract period.

**781-3.8*12*.3 Pre-installation Field Testing:** Conduct pre-installation tests on all units at a Contractor-provided facility within the appropriate District. Perform the tests on each unit supplied to verify that no damage was done to any sign during the shipment and delivery process. Notify the Engineer a minimum of 10 calendar days before the start of any tests. Conduct all tests according to the approved test procedures detailed in this section. Each DMS *must* ~~shall~~ pass the individual tests detailed below prior to installation.

**781-3.8*12*.3.1 Product Examination Test:** Examine each DMS carefully to verify that the materials, design, construction, markings, and workmanship comply with all applicable standards, specifications, and requirements.

**781-3.8~~1~~*12*.3.2 Continuity Test Specifications:** Check the wiring to determine conformance with the applicable standards, specifications, and requirements.

**781-3.8~~1~~*12*.3.3 Operational Test Specifications:** Operate each DMS long enough to permit equipment temperature stabilization, and to check and record an adequate number of performance characteristics to ensure compliance with applicable standards, specifications, and requirements.

**781-3.8~~1~~*12*.3.4 Pre-installation Test Failure Consequence:** If any unit fails to pass an FDT, 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 an FDT failure, a report shall be prepared and delivered to the Engineer prior to the unit's shipment. 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 Department or an extension of the contract period.

**781-3.8~~1~~*12*.4 Installed Site Tests:** Conduct an approved, stand-alone equipment installation test at the field site. Test all stand-alone (i.e., non-network) functions of the field equipment using equipment installed as detailed in the plans, ~~or~~ *and* as ~~directed~~ *approved* by the Engineer.

Complete approved data forms and turn them over to the Engineer for review, and as a basis for rejection or acceptance. Provide a minimum notice of 30 calendar days prior to all tests to permit the Engineer or his representative to observe each test.

If any unit fails to pass its stand-alone test, correct the unit or substitute another unit in its place, then repeat the test.

If a unit has been modified as a result of a stand-alone test failure, prepare a report describing the nature of the failure and the corrective action taken and deliver it to the Engineer prior to re-testing the unit. If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the Department or an extension of the contract period.

**781-3.8~~1~~*12*.5 System Testing:** Conduct approved DMS system tests on the field equipment with the master equipment including, at a minimum, all remote control functions. Display the return status codes from the sign controller for a minimum of 72 hours. Complete approved data forms and turn them over to the Engineer for review, and as a basis for rejection or acceptance.

Demonstrate the sign's ability to display the proper predefined message or remain blank when power is restored following an AC power interruption.

If the system test fails because of any subsystem component, repair that component or substitute another in its place, then repeat the test. If a component has been modified as a result of a system test failure, prepare a report and deliver it to the Engineer prior to retesting.

***781-3.12.6 Operational Testing:*** *After the ADMS system installation and system testing are successfully completed, conduct one continuous 72-hour, full-operating test prior to conducting the 60-day Acceptance Test. The Engineer will*

*approve the type of tests to be conducted. Include in the tests all control, monitoring, and communication functions of the field equipment by the master equipment.*

***781-3.12.7 Acceptance Testing:*** *Commence the 60-day test period on the first day after the successful completion of the approved 72-hour Operational test. During the 60-day test period, limit downtime due to mechanical, electrical, or other malfunctions to a maximum total of 5 calendar days. If the equipment fails to operate for a total of five or more calendar days, testing will be restarted. The Engineer may select to pause and extend the 60-day test period by the number of days lost by failure and repair time in lieu of restarting the full 60-day test. The Engineer will furnish the Contractor with a letter of approval and completion stating the first and last day of the 60-day test period.*

~~**781-3.8.6 Operational Testing:** After the DMS system installation and system testing are successfully completed, conduct one continuous 72-hour, full-operating test prior to conducting the 60-day test period. The Engineer will approve the type of tests to be conducted. Include in the tests all control, monitoring, and communication functions of the field equipment by the master equipment.~~

~~Commence the 60-day test period on the first day after the successful completion of the approved continuous 72-hour, full-operating test period.~~

~~During the 60-day test period, limit downtime due to mechanical, electrical, or other malfunctions to a maximum of 5 calendar days. The Engineer may extend the 60-day test period by the number of days equal to the downtime in excess of 5 calendar days.~~

~~The Engineer will furnish the Contractor with a letter of approval and completion stating the first and last day of the 60-day test period.~~

~~Final system acceptance is defined as the time when all work and materials described in the plans have been furnished and completely installed by the Contractor; all parts of the work have been approved and accepted by the Engineer; and the DMS system has been operated continuously and successfully for 60 calendar days with no more than a total of 5 calendar days non-operation due to mechanical, electrical, or other malfunctions. If the equipment fails to operate for more than 5 calendar days during final system acceptance testing, testing will be restarted.~~

**INTELLIGENT TRANSPORTATION SYSTEMS–DYNAMIC MESSAGE SIGNS. (REV 1-22-09)**

ARTICLE 781-1 (of the Supplemental Specifications) is deleted and the following substituted:

**781-1 Description.**

Furnish and install Motorist Information Systems meeting the general requirements of 781-2, the specific requirements for each system as defined in 781-3 through 781-6 of this specification, and in accordance with the details specified in the Contract Documents. Use only equipment and components that meet the requirements of these minimum specifications, and are listed on the Department's Approved Product List (APL).

ARTICLE 781-3 (of the Supplemental Specifications) is deleted and the following substituted:

**781-3 Dynamic Message Signs.**

**781-3.1 Dynamic Message Sign with 18" Character Display (18" DMS):** Furnish and install an 18" DMS in accordance with the details specified in the Contract Documents.

**781-3.1.1 General:** Ensure that all exposed material is corrosion resistant. Ensure that the electronic equipment associated with the sign remains secure from damage and protected from moisture, dust, dirt, and corrosion.

Ensure that ambient magnetic or electromagnetic fields, including those created by any system components, have no negative effects on system performance. Ensure that the system does not conduct or radiate signals that interfere with other electrical or electronic equipment including, but not limited to, other control systems and data processing, audio, radio, and industrial equipment.

Ensure that the sign housing complies with the fatigue resistance requirements of the fifth edition AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals with current addendums. Design and construct the DMS unit for continuous usage of at least 20 years and the sign structure for a 50-year design life. Ensure that equipment and structures are designed to withstand the wind loads defined in the FDOT Structures Manual without deformation or damage. Ensure that the sign is fabricated, welded, and inspected in accordance with the requirements of the current ANSI/AWS Structural Welding Code-Aluminum. Ensure that all identification markings on the sign and its components, including but not limited to panels, terminal blocks, and printed circuit boards, are silk-screened and sealed or otherwise indelible. Ensure that the equipment design allows access and maintenance without special tools. Ensure that all component parts are accessible for inspection and maintenance. Provide labeled test points for checking essential voltages. Ensure that all external connections are terminated using connectors. Key the connectors to preclude improper hookups. Provide a clear removable cover

measuring 0.125 inch thick to cover all exposed power terminals. Ensure that the covers do not interfere with sign functions or maintenance operations.

**781-3.1.2 Sign Housing:** Ensure that the external skin of the sign housing is constructed of aluminum alloy 5052 H32 that is a minimum of 0.125 inch thick. Ensure that the sign housing design and appearance is approved by the Engineer. If cable attachments are used in the sign housing, the cables shall be securely clamped using a method approved by the Engineer. No adhesive attachments shall be allowed.

Ensure that exterior seams and joints, except the finish coated face pieces, are continuously welded using an inert gas welding method. Limit the number of seams on the top of the housing to a maximum of three. Stitch weld the exterior housing panel material to the internal structural members to form a unitized structure.

Ensure that exterior mounting assemblies are fabricated from aluminum alloy 6061 T6 extrusions a minimum of 0.1875 inch thick.

Ensure that sign provides a minimum legible viewing distance that includes the area from 100 to 1100+ feet in advance of the sign. Ensure that the sign is legible for a minimum of 10 seconds when viewed from an approaching vehicle moving at the posted speed.

Ensure that the bottom panel of the sign housing includes a minimum of four drain holes with replaceable plugs that serve to open and close the drain. Ensure that the drain holes are centered from the front to the back of the housing, and equally spaced across the housing's full length. Ensure that all drain holes and other openings in the sign housing are screened to prevent the entrance of insects and small animals. Ensure that the bottom panels are sloped towards the drain holes to prevent water accumulation on the interior surfaces of the sign bottom.

Ensure that the top of the housing includes multiple steel lifting eyebolts or equivalent hoisting points. Ensure hoist points are attached directly to structural frame members by the sign manufacturer. Ensure hoist points are positioned such that the sign remains level when lifted. Ensure that the hoist points and sign frame allow the sign to be shipped, handled, and installed without damage.

**781-3.1.2.1 Interior Structure:** Ensure that framing structural members are constructed of aluminum alloy (6061 T6 or 6063 T5) a minimum of 0.1875 inch thick.

Construct the sign housing with a minimum width of 34 inches. Provide an interior walkway with a minimum width of 2 feet. Ensure that the walkway area maintains a minimum of 2 feet of horizontal clear area and 6 feet of clear height along the sign housing's entire length. Fabricate the walkway from diamond tread plate 6061-T6 or 3003-H22 aluminum that is 0.125 inch thick. Finish all edges of the walkway to eliminate sharp edges or protrusions.

**781-3.1.2.2 Housing Face:** Ensure that housing face consists of internal structural members, external fascia panels, and lens panel assemblies. Do not allow exposed fasteners on the housing face.

**781-3.1.2.2.1 Internal Structural Members:** Ensure that internal structural members are constructed of extruded aluminum and accommodate both display module mounting and air distribution. Ensure that the internal structural members retain the display modules in a manner that facilitates the easy and rapid removal of each display module from within the sign without disturbing adjacent display modules.

**781-3.1.2.2.2 External Fascia Panels:** Ensure that external fascia panels are constructed using aluminum. Ensure fascia panels are sealed to prevent intrusion of water, moisture, dust, dirt, and other contaminants into the sign interior. Finish each fascia panel with a matte-black coating system that meets or exceeds American Architectural Manufacturers Association (AAMA) Specification No. 2605. Ensure that the external fascia perimeter panels are a minimum of 1 foot wide. Ensure that external fascia interline panels are a minimum of 9 inches wide.

**781-3.1.2.2.3 Lens Panel Assembly:** Provide lens panel assemblies that are modular in design, removable, and interchangeable without misalignment of the lens panel and the LED pixels, and that are removable from within the main sign housing. Ensure that lens panels include a mask constructed of 0.080 inch minimum thickness aluminum with a matte black coating that meets or exceeds AAMA Specification No. 2605 with a minimum thickness of 0.04 inch. Ensure that the mask is perforated to provide an aperture for each pixel on the display module. Ensure that the apertures are uniform, centered over each pixel, and as small as possible without blocking the LED output at the required viewing angle.

Ensure the lens panel assembly consists of LEDs, other internal electronics, an aluminum mask, and an environmental shielding layer coating to protect and seal the LEDs and other internal electronics. The coating shall be a minimum 90% ultraviolet (UV) opaque.

**781-3.1.2.3 Sign Housing Surface Finish:** Ensure that all sign face surfaces are finished with a matte black FP-based coating system that meets or exceeds AAMA Specification No. 2605. Provide certification that the sign face parts are coated with the prescribed thickness. Ensure all other exterior and all interior housing surfaces are a natural aluminum mill finish. No interior painted surfaces will be allowed.

**781-3.1.2.4 Sign Housing Access Door:** Provide a three-point, lockable, aluminum access door at the end of the housing, as depicted in the plans, to permit easy access to the walk-in housing. The access door shall be a minimum height of 80 inches and a minimum width of 2 feet. Outfit the door with a handle-operated locking mechanism, closed-cell neoprene gasket, and stainless steel hinges.

Furnish a locking mechanism that is a Grade 1 three-point, center-case dead bolt lock conforming to ANSI/BHMA Standard A156.2 and having a zinc finish. Provide a handle on both the inside and outside of the door. Ensure that handles are heavy duty, industrial strength, and corrosion resistant. Include a device in the door assembly to hold the door open at 90 degrees. Ensure that the door is monitored electronically by the sign controller and provides an alert to transportation management center (TMC) personnel whenever the door is opened.

**781-3.1.2.5 Sign Housing Ventilation System:** Provide a ventilation system that distributes air over all LEDs, power supplies, and communication devices inside the sign housing. Ensure that air circulation is evenly distributed across display modules, in the cavity between each display module, across lens panels and the back of the display modules. Submit ventilation system design calculations to the Engineer for approval.

Ensure that air drawn into the sign is filtered upon entry. Ensure that filters remove airborne particles measuring 500 microns in diameter and larger.

Ensure that the ventilation system is automatically tested once each day, and that it may be tested on command from remote and local control access locations. Ensure that the sign controller will send an error message to the TMC or a laptop computer when a failure occurs. Ensure that the sign is capable of operating without any decrease in performance over an ambient operating temperature range of -29° to 165°F as per NEMA TS 4, Subsection 2.1.5.1, with a maximum relative humidity of 100%.

Ensure that the sign includes a fail-safe ventilation subsystem that includes a snap disk thermostat that is independent of the sign controller. Preset the thermostat at 130°F. If the sign housing's interior reaches 130°F, the thermostat will override the normal ventilation system, bypassing the sign controller and turning on all sign ventilation fans. The fans will remain under the control of the thermostat until the internal sign housing temperature falls to 115°F, at which time the fail-safe subsystem will return control of the ventilation system to the sign controller.

Ensure that the sign includes a manual override timer switch located just inside the access door to manually activate the ventilation system. The switch must be adjustable up to four hours.

Ensure that the sign includes a sensor or a sensor assembly to monitor airflow volume to predict the need for a filter change. Ensure that the ventilation system fans possess a 100,000-hour L10 life rating.

**781-3.1.2.6 Sign Housing Temperature Sensor:** Ensure that the sign controller continuously measures and monitors the temperature sensors. Ensure that the sign can be programmed to blank when a user-defined critical temperature is exceeded. Ensure that the sign will report such events when polled. Ensure that the user-selectable, critical temperature may be changed by remote and local control access. Ensure that remote and local computers can read all temperature measurements from the sign controller. When the sign reaches a temperature that is 2°F lower than the critical high temperature, ensure that the sign controller will decrease the LED intensity to half its normal brightness.

**781-3.1.2.7 Sign Housing Humidity Sensor:** Ensure the sign includes a humidity sensor that detects from 0 to 100% relative humidity in 1% or smaller increments. Ensure that the sensor will operate and survive in 0 to 100% relative humidity, and has an accuracy that is better than ±5% relative humidity. A humidistat is not acceptable.

**781-3.1.2.8 Photoelectric Sensor Devices:** Ensure the sign electronics monitor ambient light using a minimum of three photocells. Ensure that the photocells are placed so they measure light levels on the front and rear of the sign, and ambient light conditions at the sign location. Ensure that the devices provide accurate ambient light condition information to the sign controller for automatic light intensity adjustment. Ensure that the automatic adjustment of the LED driving waveform duty cycle occurs in small enough increments that the sign's brightness changes smoothly, with no perceivable brightness change between adjacent levels. Ensure that stray headlights shining on the photoelectric sensor at night do not cause LED brightness changes.

Supply the sign with a brightness-versus-ambient light matrix table with algorithms and/or other means of calculation that enables the sign to

automatically adjust LED output according to ambient light level. Ensure the sign controller monitors the photocell circuits in the sign and correlates the readings with the brightness table to convert the measured light intensity into the desired pixel brightness. Ensure that the brightness table has a minimum of 255 levels. Ensure that the brightness table in each individual sign controller is adjustable from the TMC or a laptop computer, and can be customized according to each installation site's requirements. Ensure that the sign controller automatically controls the pixel brightness to compensate for differences in ambient light levels, such as the differences in day and night. In addition to the automatic mode, ensure that the brightness may be set from 1% to 99% in 1% increments manually from the front panel of the sign controller and remotely from the TMC.

Ensure that the brightness and color of each pixel is uniform over the sign's entire face within a 15-degree viewing angle from 200 to 1,100 feet in all lighting conditions. Non-uniformity of brightness or color over the sign's face shall be cause for rejection of the sign.

**781-3.1.2.9 Sign Housing Internal Lighting and Electrical Outlets:** Furnish the sign housing with a minimum of four internal fluorescent or incandescent light fixtures. Near the door, locate a 12-hour timer without a hold feature for the lights.

If incandescent lamps are provided, ensure that they are spaced evenly above the walkway and fully enclosed in heavy-duty shatterproof, protective fixtures. Ensure that incandescent fixtures include aluminum housing and base, a porcelain socket, and clear glass inner cover. Ensure that all removable components are secured with set screws.

If fluorescent lamps are provided, ensure that the fixtures are spaced evenly above the walkway and fitted with protective guards.

Ensure that the sign housing includes emergency lighting that automatically illuminates the interior in the event of a power outage.

Ensure that the light produced from internal lighting is not visible from outside the sign during nighttime or other dark conditions and does not interfere with normal visible operation of the sign.

Equip each sign housing with at least three 15-amp, 120-volt rated ground fault interrupter (GFI) outlets that include protected duplex electrical receptacles. Locate one duplex receptacle at each end of the sign housing and one at the center of the sign housing. Space the duplex receptacles evenly on the rear wall of the housing at a maximum height of 3 feet above the walkway.

**781-3.1.3 Display Modules:** Provide display modules manufactured by one source and fully interchangeable throughout the manufacturer's sign system(s). Ensure that removal of a single display module does not impact the operation of other display modules. Ensure that removal or replacement of a complete display module or LED board can be accomplished without the use of any tools.

Ensure display modules contain solid-state electronics needed to control pixel data and read pixel status.

**781-3.1.3.1 Line Matrix Display Module:** Assemble display modules in a line matrix configuration consisting of three lines of 25 display modules per line. Ensure each line consists of an array, 7 pixels high by 125 pixels wide, allowing an 18-inch-high display of 5 pixel by 7 pixel characters per line with double-column spacing

between the characters. Ensure that the line matrix display module includes an LED board containing a minimum of 35 pixels in a 5 pixel by 7 pixel configuration capable of displaying 18 inch dot matrix characters.

**781-3.1.3.2 Full Matrix Display Module:** Assemble display modules to form a full matrix configuration consisting of three lines of 25 display modules per line providing an arrangement of 27 pixels by 125 pixels. Ensure that the display will allow an 18-inch-high display per line with 5 pixel by 7 pixel characters and double column spacing between the characters. Ensure that the full matrix display module includes an LED board containing 45 pixels arranged uniformly in 5 columns of 9 pixels each to form a 5 pixel by 9 pixel array capable of displaying 18-inch dot matrix characters.

**781-3.1.3.3 LED and Pixel Specifications:** Ensure that the sign utilizes amber, three-quarter diode LED lamps with a minimum viewing angle of 15 degrees and a peak wavelength of 590 nanometers. Ensure that the LED peak wavelength output varies no more than ±2 nanometers. Ensure that the LED pixel cone of vision is a minimum of 15 degrees (centered around the optical axis, or zero point, of the pixel). The cone perimeter is defined by the point where light output intensity is 50% of the intensity measured at the zero point of the pixel.

Ensure that each pixel has a diameter of 1.5 inches, ±10%, and that the LEDs in each pixel are clustered to maximize long-range visibility. Ensure that all pixels in all signs in a project, including operational support supplies, have equal color and on-axis intensity. Ensure that each pixel's on-axis intensity is a minimum of 40 candelas when operating at 100% intensity. Measure the brightness of each LED in accordance with the International Commission on Illumination's (CIE) requirements as detailed in Test Method A of the CIE 127 (1997) standard. Provide the LED brightness and color bins that are used in each pixel to the Engineer for approval. Provide a letter of certification from the LED manufacturer that demonstrates testing and binning according to the CIE 127 (1997) standard.

Ensure each pixel contains two interlaced circular strings of LEDs powered from a regulated power source providing a maximum of 25 volts of direct current ($V_{DC}$). Ensure that LED power current is maintained at 25 milliamperes, ±2 milliamperes. Ensure that LED failure in one string within a pixel does not affect the operation of any other string or pixel. Do not exceed 1.5 watts per pixel for power drawn from a direct current (DC) supply, including the driving circuitry.

Provide a pixel test as a form of status feedback to the TMC from the local sign controller. Ensure that the operational status of each pixel in the sign can be automatically tested once a day. The operational status may also be tested when the TMC or a laptop computer prompts a pixel test. Ensure that a log file can be created containing a list of defective pixels as transmitted to the TMC or a laptop computer. Ensure that the log file includes the pixel status, module number, column number, and pixel number. Ensure that the pixel status test determines the functional status of the pixel as stuck-on or stuck-off and does not affect the displayed message for more than half a second.

Ensure that LEDs are individually mounted directly on a PCB, and are individually removable and replaceable using conventional electronic repair methods. **781-3.1.3. 4 Optical, Electrical, and Mechanical**

**Specifications for Display Modules:** Ensure that each display module contains connectors for power, controls, and data; contains display module control electronics and memory elements; and provides the signals to switch the LED pixels.

Ensure the display modules are rectangular and have an identical vertical and horizontal center-to-center distance (i.e., pitch) between adjacent pixels ranging from 2.6 inches to 2.75 inches. Ensure that the separation between the last column of one display module and the first column of the next module is equal to the horizontal distance between the columns of a single display module.

Ensure that the LED circuit board is a NEMA FR4-rated, single 0.062-inch, black PCB. Ensure that alternate LED board configurations are submitted to and pre-approved by the Engineer prior to installation. Ensure that PCBs enable components to be removed and replaced without damage to boards, traces, or tracks. Ensure that the intercomponent wiring is a copper-clad track having a minimum weight of 2 ounces per square foot with an adequate cross section for carrying circuit current. Ensure that no PCB has more than two PCB jumper wires present. Finish all PCBs with a solder mask and a component-identifying silk screen.

Provide all PCBs, except for the LED motherboard and power supply PCBs, with a complete and conformal coating of silicone resin with a minimum thickness of 0.01 inch. Provide the LED motherboards with a complete conformal coating of silicone resin with a minimum thickness of 0.01 inch, except for the pixels on the front of the PCB. Meet the material requirements of MIL-I-46058C Military Standard, United States Department of Defense (USDOD).

Mount all LEDs so that the mechanical axis of the LED is ±1 degree to the sign's face to ensure uniformity of brightness over the sign's face.. Ensure that LEDs are secured perpendicular to the display module within 0.5 degree and may be easily removed from the display module PCB without tools. Ensure that any devices used to secure LEDs do not block air flow to the LED leads or block the LED light output at the required viewing angle. Ensure that all components on the LED side of PCBs are black.

Ensure that the voltage to the LED modules and their associated electronics does not exceed 25 $V_{DC}$. Ensure that there are a minimum of two, and a maximum of four, power supplies that are wired in a parallel configuration for redundancy. Ensure that multiple power supplies are used to provide power to each display module. Ensure the voltage measured at the display modules does not vary more than 50 millivolts over all the display modules in the sign with 17 pixels on at 100% intensity in each display module. Ensure that if one supply completely fails, the sign shall still be supplied with enough power to run 40% of all pixels at a 100% duty cycle with an ambient operating temperature of 165°F. Ensure that the supplies have a current sharing capability that allows them to provide equal amounts of current to their portion of the LED display.

Ensure that the sign controller continuously measures and monitors all LED module power supply voltages and provides the voltage readings to the TMC or a laptop computer on command. Ensure that an error message will be sent to the TMC or a laptop computer when it polls the sign controller if voltages measured are outside nominal values.

Ensure that LEDs are protected from external environmental conditions, including moisture, snow, ice, wind, dust, dirt, and UV rays. Do not use hoods, louvers, cylinders or visors that could impede the free flow of air over any surface of each individual LED. Do not use epoxy to encapsulate the LEDs.

**781-3.1.4 Character Displays:** Ensure that the signs are capable of displaying American Standard Code for Information Interchange (ASCII) characters 32 through 126, including all uppercase and lowercase letters and digits 0 through 9, at any location in the message line.

Ensure that the uppercase alphanumeric characters are displayed over the complete height of the matrix. Submit a list of the character fonts to the Engineer for approval.

Characters must be legible under all light conditions at a distance ranging from 200 to 1,100 feet within the 15-degree cone of vision centered on the pixel's optical axis. Ensure that the operator is able to display compressed (i.e., 4 pixel by 7 pixel), expanded (i.e., 6 pixel by 7 pixel), or double-stroke (i.e., 7 pixel by 7 pixel) character fonts, and to change the default spacing between characters. Ensure that the spacing options include 1-, 2-, or 3-pixel columns between the characters. Ensure the system is loaded with a default font in accordance with the Standard Font set described in NEMA TS4-2005 (section 5.6). Ensure the system allows the assignment of font access privileges. Ensure that the sign controller is capable of a self-updating time and/or date display on the sign.

Ensure that the sign controller allows a moving arrow to be displayed on one line with a standard text message on the other lines. Ensure that the moving arrows may be shown moving from the left or right, and starting from one end or in the middle of the sign and continuing to the end of the sign.

**781-3.1.5 Main Power Supply and Energy Distribution Specifications:** Provide a nominal single-phase power line voltage of 120/240 $V_{AC}$ protected by one 60-amp, two-pole (i.e., common trip) main circuit breaker for the sign and its controller. Ensure that the system operates within a voltage range of 97 to 135 $V_{AC}$ as specified in NEMA TS 4, Subsection 2.1.3.1.

Ensure that all service lines inside the sign housing are supplied by 120 $V_{AC}$ independently protected by a thermomagnetic circuit breaker at the sign housing's entry point. Locate all 120 $V_{AC}$ wiring in conduit, pull boxes, raceways, or control cabinets as required by the NEC. Ensure that no 120 $V_{AC}$ wiring is exposed inside or outside of the sign housing. Do not use the sign housing as a wiring raceway or control cabinet.

Ensure that the sign and its controller have an operating frequency of 60 hertz (Hz), ±3.0 Hz, as stated in NEMA TS 4, Subsection 2.1.3.2. Ensure that the drop in the unit's voltage between no-load and full-load during normal operations does not exceed 10% of the nominal voltage. Provide power protection through the use of a thermomagnetic circuit breaker connected to a 5-milliampere GFI device that protects all service outlets. Provide a 100-amp 120/240 $V_{AC}$ two-pole load center with a 20-circuit capability. Provide separate circuit breakers for each sign circuit.

Provide Type XHHW power cables sized as required by the NEC for acceptable voltage drops while supplying alternating current to the sign. Ensure that the sign power consumption does not exceed 7,000VA under any circumstance, including

operation of the fans, heaters (if provided within the sign), sign controllers and communication equipment, and all pixels illuminated at 100% brightness.

Provide protection devices such as surge suppressors and lightning arrestors installed or incorporated in the sign system by the manufacturer to guard against lightning, transient voltage surges, and induced current. Ensure that the protection devices meet or exceed the device protection requirements as contained in Section 785-2. Use protection devices on all electric power and data communication connections.

Ensure that the DC and AC voltage ratings and dissipation factors of capacitors used in the sign system exceed the worst-case design parameters of the circuitry by 50%. Ensure that capacitors that are not surface mount components are mechanically supported by a clamp or fastener that is resistant to cracking, peeling, and discoloration.

Ensure that resistors used in the sign are within 5% of the tolerance of the specified temperature range and, when operated in excess of 50% of its power rating, have an adequate heat sink.

Ensure all transistors, integrated circuits, and diodes are a standard type, listed by the EIA, and clearly identifiable.

**781-3.1.6 Uninterruptible Power Supply:** Provide each sign with an uninterruptible power supply (UPS) capable of maintaining and continuing the operation of the sign and its related communication device for a minimum of two hours. Provide sealed AGM type batteries that are maintenance free. Ensure that the UPS is installed within the sign housing or as shown in the plans.

**781-3.1.7 Operational Support Supplies:** Furnish the operational support supplies listed in the table below. Promptly replace any of the supplies used to perform a warranty repair.

For every group of 10 or fewer 18” DMS provided or required, provide 1 set of supplies as follows:

| | |
|---|---|
| 1 each | Sign Controller |
| 10 each | LED Display Modules |
| 1 each | Uninterruptible Power Supplies |
| 1 each | System Interface Circuit |
| 1 each | Cable for connecting interface circuits to daughter boards |
| 1 each | Display Module Cables |
| 2 each | Surge Suppression Sets |
| 1 each | Fan Assembly |
| 1 each | Time Relay for Fan Control |
| 10 each | Every Small Fuse (< 10 amp) |
| 2 each | Every Large Fuse (> 10 amp) |
| 1 each | Sensor for each type of sensor |

The Engineer will review and approve the operational support supplies.

**781-3.1.8 Sign Controller:** Ensure that the sign is provided with a sign controller that includes operational firmware stored in nonvolatile memory. Program the

controller to receive sign control commands from the TMC, to transmit responses (as requested) to the TMC, and to control sign operation and message displays. Ensure that sign controller functions include error logging and reporting, and providing the operational status of the sensors including temperature, photocell, airflow, humidity and LED power supply sensors.

Ensure that the sign controller will read the internal temperature sensors, the external ambient temperature sensors, and the humidity sensors and use the readings in an algorithm that turns on heat tape and/or fans when conditions warrant to prevent frost on the face of the sign and condensation on the display modules and other electronic circuitry.

Ensure that the sign controller receives and sends messages by way of an Ethernet network and that the failure of any sign does not affect the operation of any other sign in the system.

Ensure that, at a minimum, the sign controller consists of local control panel status indicators including power on/off, TMC communication status, laptop computer communication status, communication status with the electronics in the walk-in housing, and sign diagnostics and error status.

Ensure that the controller provides power-up and automatic restart capabilities with automatic sign blanking when recovering from a power-off condition. Ensure that the sign can be configured to either display a stored message or blank upon recovery from power loss and upon recovery from system resets. Utilize a hardware watchdog circuit to provide automatic recovery from critical errors and automatic shutdown in the event of critical hardware failure.

Mount the sign controller within the sign housing using industry standard keyed-type connectors with a retaining mechanism. Ensure that there is a ground level access point at the sign location that allows the sign to be programmed and controlled locally using a laptop computer.

**781-3.1.9 Display System Hardware:** Ensure the sign utilizes a system data interface circuit for communication between the sign controller and display modules. Ensure the following components reside inside the walk-in housing: sign controller, display system interface circuits, display modules, power supplies, local and remote control switches, LED indicators, an Electronic Industries Alliance (EIA)-232 plug-in connection for laptop computers, EIA-232 null modem cables (minimum of 4 feet long for connecting laptop controller to sign controller), workspace for a laptop computer, and communication equipment and transient voltage surge suppressors.

**781-3.1.10 Control Cabinet Specifications:** Provide a control cabinet that meets the requirements of Section 785-4.

Equip the ground control cabinet with the following assemblies and components, unless otherwise specified in the plans: power indicator, surge suppression on both sides of all electronics, communication interface devices, connection for a laptop computer for local control and programming, cables a minimum of 4 feet long to connect laptop computers, and duplex outlets.

Provide for all telephone, data, control, power, and confirmation connections between the sign and ground control box, and for any required wiring harnesses and connectors.

**781-3.1.11 Sign Controller Communication Interface:** Ensure that the sign controller includes two separate EIA-232 serial interfaces inside the sign housing for communication with the TMC or a laptop computer, and one Ethernet 10/100 Base TX 8P8C port. Ensure that EIA-232 serial interfaces support the following:

Data Bits: 7 or 8 bits

Parity: Even, Odd, None, Mark, or Spare

Number Stop Bits: 1 or 2 bit

Ensure that all Category 5 unshielded twisted pair/shielded twisted pair network cables are compliant with the EIA/TIA-568-A standard.

Configure one EIA-232 serial interface to drive asynchronous modems for full duplex communication with the TMC over point-to-point dial-up lines or a multidrop fiber or copper network. Ensure that switching between dial-up, Ethernet, and multidrop operation does not require sign controller software or hardware modifications.

For dial-up operations, acquire and bear the charges of installing and connecting the dial-up telephone line. Provide modems to be retained by the Department at each location. Provide a user-selectable data transmission rate of up to 19.2 kbps for dial-up operations.

Configure the second EIA-232 serial port for local communication with a laptop computer.

Ensure that the sign controller can be managed remotely from a TMC or locally using a laptop computer. Ensure that the TMC or a laptop computer can be used to remotely reset the sign controller.

Ensure that the sign controller and its software will display single-page and multi-page messages, with mixed fonts and spacing. Ensure that message page times and text flashing rates are programmable between 0.5 and 5 seconds in 0.1-second increments.

Ensure that the sign system will log and report errors and failures, including data transmission errors, receipt of invalid data, communication failure recoveries, alternating current power failures, power recoveries, pixel status reads, fan and filter airflow status, temperature status, power supply status, and information on the operational status of the temperature, photocell, airflow, humidity, and LED power supply sensors. Ensure that airflow and humidity sensor information is reported using the objects from the dmsClimateCtrlStatusTable of the NTCIP 1203 V2 standard.

**781-3.1.12 Message and Status Monitoring:** Ensure that the sign provides two modes of operation: (1) master operation, where the TMC commands and controls the sign and determines the appropriate message or test pattern; and (2) local operation, where the sign controller or a laptop computer commands and controls the sign and determines the appropriate message or test pattern.

Keep electronic components away from the access door to protect them from the elements. Ensure that the walk-in housing containing the local control panel has switches that perform the following functions:

1. Control Selection – Ensure that the local/remote switch on the local control panel works in parallel with the local/remote switch located in the ground control box. Provide a LED indicator near the local/remote switch to indicate when either switch has selected the local mode. The operating mode is determined by the

position of the mode switch on the local control panel. If the local control panel's switch is set to local, the operating mode is local. Otherwise, the operating mode is master.

2. Message Selection – Ensure that the sign controller's keypad may be used to select a blank message or any one of the messages stored in the sign controller's nonvolatile memory when the control mode is set to local.

3. Message Implementation – Ensure that the sign controller can activate the selected message.

Ensure that the sign controller transmits a return message to the TMC whenever it receives a valid status request. Ensure that return messages contain an Internet Protocol (IP) address for the sign controller, the actual message that is visibly displayed on the sign, the displayed message's transmission origin (i.e., the TMC, laptop computer, manual entry, etc.), remote or local control status, error and failure reports, temperature readings, access alarms, power supply voltage levels, line voltage, and UPS status.

In the event of a sign controller failure, ensure that the sign controller blanks any message displayed. Ensure that the sign can be programmed to display a user-defined message, including a blank page, in the event of power loss.

Ensure that message additions, deletions, and sign controller changes may be made from either the remote TMC or a local laptop computer. Ensure that each font may be customized, and modifications to a font may be downloaded to the sign controller from the TMC or a laptop computer at any time without any software or hardware modifications. Ensure the sign is capable of displaying a different font and character spacing on each line.

Ensure that messages can be activated with a run-time duration specified. Ensure that the sign can be programmed to display a user-defined message, including a blank page, once the run-time duration of another message has expired. Ensure that there is no perceivable flicker or ghosting of the pixels during sign erasure and writing periods.

Ensure that in the event of an AC power loss all nonvolatile memory is retained for a minimum of 30 calendar days. Ensure that the sign controller monitors the messages downloaded from the TMC or laptop computer to make sure that the message will fit in the display area of the sign. Ensure that the sign controller's internal time clock provides for message deactivation at the correct time, even in the event of a communication loss. Ensure that the sign controller maintains its internal clock during power outages and automatically displays the proper message when power is restored within 255 minutes. Ensure that the sign can also be programmed to automatically blank the display following a power outage longer than 255 minutes.

**781-3.2 Dynamic Message Sign with 12-inch Character Display (12" DMS):** Furnish and install a 12" DMS in accordance with the details specified in the Contract Documents. **781-3.2.1 General:** Ensure that all exposed material is corrosion resistant. Ensure that the electronic equipment associated with the sign remains secure from damage and protected from moisture, dust, dirt, and corrosion.

Ensure that ambient magnetic or electromagnetic fields, including those created by any system components, have no negative effects on system performance. Ensure that the system does not conduct or radiate signals that interfere

with other electrical or electronic equipment including, but not limited to, other control systems and data processing, audio, radio, and industrial equipment.

Ensure that the sign housing complies with the fatigue resistance requirements of the fifth edition AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals with current addendums. Design and construct the sign for continuous usage of at least 20 years and the sign structure for a 50-year design life. Ensure that equipment and structures are designed to withstand the wind loads defined in the FDOT Structures Manual without deformation or damage.

Ensure that the sign is fabricated, welded, and inspected in accordance with the requirements of the current ANSI/AWS Structural Welding Code-Aluminum. Ensure that all identification markings on the sign and its components, including but not limited to panels, terminal blocks, and printed circuit boards, are silk-screened and sealed or otherwise indelible. Ensure that the equipment design allows access and maintenance without special tools. Ensure that all component parts are accessible and available for inspection and maintenance for the duration of the system design life. Provide labeled test points for checking essential voltages. Ensure that all external connections are terminated using connectors. Key the connectors to preclude improper hookups. Provide a clear removable cover measuring a minimum of 0.125 inch thick to cover all exposed power terminals. Ensure that the covers do not interfere with sign functions or maintenance operations.

**781-3.2.2 Sign Housing:** Ensure that the non-display external skin of the sign housing is constructed of aluminum alloy 5052 H32 that is a minimum of 0.090 inch thick. Ensure that the sign housing design and appearance is approved by the Engineer. If cable attachments are used in the sign housing, the cables shall be securely clamped using a method approved by the Engineer.

Ensure housing exterior is attached to the structural framework using a method approved by the Engineer. Ensure the housing bevel of the housing face is not greater than 1 foot on any side. Ensure housing provides an environmental seal for internal components with a minimum rating of IP54. Ensure all openings in housing (such as vents and drain holes) are safeguarded against the entrance of insects and animals.

Ensure LED display module(s) are mounted such that the legible viewing area is optimized.

Ensure all assembly hardware is in accordance with sections 603-2.4 and 603-2.5.

Ensure housing includes a method of hoisting to allow for proper mounting of device via use of standard construction equipment. Ensure the sign remains level when hoisted. Ensure hoisting design prevents damage when device is shipped, handled, and installed.

**781-3.2.2.1 Interior Structure:** Ensure that framing structural members are constructed of aluminum alloy (6061 T6 or 6063 T5) a minimum of 0.1875 inch thick.

**781-3.2.2.2 Housing Face:** Ensure that housing face consists of internal structural members, external fascia panels, and lens panel assemblies. Do not allow exposed fasteners on the housing face.

**781-3.2.2.2.1 Internal Structural Members:** Ensure that internal structural members are constructed of extruded aluminum. Ensure that the internal structural members retain the display modules in a manner that facilitates the easy and rapid removal of each display module without disturbing adjacent display modules.

**781-3.2.2.2.2 External Fascia Panels:** Ensure that external fascia panels are constructed using aluminum. Ensure fascia panels are sealed to prevent intrusion of water, moisture, dust, dirt, and other contaminants into the sign interior. Finish each fascia panel with a matte black coating system that meets or exceeds American Architectural Manufacturers Association (AAMA) Specification No. 2605.

**781-3.2.2.2.3 Lens Panel Assembly:** Provide lens panel assemblies that are modular in design, removable, and interchangeable without misalignment of the lens panel and the LED pixels. Ensure that lens panels include a mask constructed of 0.080 inch minimum thickness aluminum with a matte black coating that meets or exceeds AAMA Specification No. 2605 with a minimum thickness of 0.04 inch. Ensure that the mask is perforated to provide an aperture for each pixel on the display module. Ensure that the apertures are uniform, centered over each pixel, and as small as possible without blocking the LED output at the required viewing angle.

Ensure the lens panel assembly consists of LEDs, other internal electronics, an aluminum mask, and an environmental shielding layer coating to protect and seal the LEDs and other internal electronics. The coating shall be a minimum 90% ultraviolet (UV) opaque.

**781-3.2.2.3 Sign Housing Surface Finish:** Ensure that all sign face surfaces are finished with a matte black FP-based coating system that meets or exceeds AAMA Specification No. 2605. Provide certification that the sign face parts are coated with the prescribed thickness. Ensure all other exterior and all interior housing surfaces are a natural aluminum mill finish. No interior painted surfaces are allowed.

**781-3.2.2.4 Sign Housing Access:** Provide unobstructed front or rear access that allows servicing of internal components. Ensure access does not require specialized tools or excessive force.

**781-3.2.2.5 Sign Housing Ventilation System:** If a ventilation system is required, ensure that it distributes air over all LEDs, power supplies, and communication devices inside the sign housing. Ensure that air circulation is evenly distributed within the housing. Submit ventilation system design calculations to the Engineer for approval.

Ensure that air drawn into the sign is filtered upon entry. Ensure that filters remove airborne particles measuring 500 microns in diameter and larger.

Ensure that the ventilation system is automatically tested once each day, and that it may be tested on command from remote and local control access locations. Ensure that the sign controller will send an error message to the designated monitoring personnel when a failure occurs. Ensure that the sign is capable of operating without any decrease in performance over an ambient operating temperature range of -29° to 165°F as per NEMA TS 4, Subsection 2.1.5.1, with a maximum relative humidity of 100%.

Ensure that any ventilation system has a fail-safe that includes a snap disk thermostat that is independent of the sign controller. Preset the thermostat at 130°F. If the sign housing's interior reaches 130°F, the thermostat will override the normal ventilation system, bypassing the sign controller and turning on all sign ventilation fans. The fans will remain under the control of the thermostat until the internal sign housing temperature falls to 115°F, at which time the fail-safe subsystem will return control of the ventilation system to the sign controller. Ensure that any ventilation system fans possess a 100,000-hour L10 life rating.

**781-3.2.2.6 Sign Housing Temperature Sensor:** Ensure that the sign controller continuously measures and monitors the temperature sensors. Ensure that the sign can be programmed to blank when a user-defined critical temperature is exceeded. Ensure that the sign will report such events when polled. Ensure that the user-selectable, critical temperature may be changed by remote and local control access. Ensure that remote and local computers can read all temperature measurements from the sign controller. When the sign reaches a temperature that is 2° F lower than the critical high temperature, ensure that the sign controller will decrease the LED intensity to half its normal brightness.

**781-3.2.2.7 Sign Housing Humidity Sensor:** Ensure the sign includes a humidity sensor that detects from 0 to 100% relative humidity in 1% or smaller increments. Ensure that the sensor will operate and survive in 0 to 100% relative humidity, and has an accuracy that is better than ±5% relative humidity. A humidistat is not acceptable.

**781-3.2.2.8 Photoelectric Sensor Devices:** Ensure the sign electronics monitor ambient light using a minimum of three photocells. Ensure that the photocells are placed so they measure light levels on the front and rear of the sign, and ambient light conditions at the sign location. Ensure that the devices provide accurate ambient light condition information to the sign controller for automatic light intensity adjustment. Ensure that the automatic adjustment of the LED driving waveform duty cycle occurs in small enough increments that the sign's brightness changes smoothly, with no perceivable brightness change between adjacent levels. Ensure that stray headlights shining on the photoelectric sensor at night do not cause LED brightness changes.

Supply the sign with a brightness-versus-ambient light matrix table with algorithms and/or other means of calculation that enables the sign to automatically adjust LED output according to ambient light level. Ensure the sign controller monitors the photocell circuits in the sign and correlates the readings with the brightness table to convert the measured light intensity into the desired pixel brightness. Ensure that the brightness table has a minimum of 255 levels. Ensure that the brightness table in each individual sign controller is adjustable from remote or local control access, and can be customized according to each installation site's requirements. Ensure that the sign controller automatically controls the pixel brightness to compensate for differences in ambient light levels, such as the differences in day and night. In addition to the automatic mode, ensure that the brightness may be set from 1% to 99% in 1% increments manually from the front panel of the sign controller and remotely from the TMC.

Ensure that the brightness and color of each pixel is uniform over the sign's entire face within a 30 degree viewing angle from 100 to 600 feet

in all lighting conditions. Non-uniformity of brightness or color over the sign's face shall be cause for rejection of the sign.

**781-3.2.3 Display Modules:** Provide display modules manufactured by one source and fully interchangeable throughout the manufacturer's sign system(s). Ensure that removal of a single display module does not impact the operation of other display modules. Ensure that removal or replacement of a complete display module or LED board can be accomplished without the use of any tools.

Ensure display modules contain solid-state electronics needed to control pixel data and read pixel status.

**781-3.2.3.1 Module Arrangement and Character Size:** Assemble display modules to form a full matrix display as shown in the plans. Ensure that the display is capable of providing a minimum character size of 12-inches when using 5-pixel by 7-pixel characters.

**781-3.2.3.2 LED and Pixel Specifications:** Ensure that the 12" DMS utilizes amber, three-quarter diode LED lamps with a minimum viewing angle of 30 degrees and a peak wavelength of 590 nanometers. Ensure that the LED peak wavelength output varies no more than ±2 nanometers. Ensure that the LED pixel cone of vision is a minimum of 30 degrees (centered on the optical axis, or zero point, of the pixel). The cone perimeter is defined by the point where light output intensity is 50% of the intensity measured at the zero point of the pixel.

Ensure that each pixel has a diameter of 1.0 inches, ±10%, and that the LEDs in each pixel are clustered to maximize long-range visibility. Ensure that all pixels in all signs in a project, including operational support supplies, have equal color and on-axis intensity. Ensure that each pixel's on-axis intensity is a minimum of 40 candelas when operating at 100% intensity. Measure the brightness of each LED in accordance with the International Commission on Illumination's (CIE) requirements as detailed in Test Method A of the CIE 127 (1997) standard. Provide the LED brightness and color bins that are used in each pixel to the Engineer for approval. Provide a letter of certification from the LED manufacturer that demonstrates testing and binning according to the CIE 127 (1997) standard.

Ensure each pixel contains two interlaced circular strings of LEDs powered from a regulated power source providing a maximum of 25 volts of direct current ($V_{DC}$). Ensure that LED power current is maintained at 25 milliamperes, ±2 milliamperes. Ensure that LED failure in one string within a pixel does not affect the operation of any other string or pixel. Do not exceed 1.5 watts per pixel for power drawn from a direct current (DC) supply, including the driving circuitry.

Provide a pixel test as a form of status feedback to the TMC from the local sign controller. Ensure that the operational status of each pixel in the sign can be automatically tested once a day. Ensure the operational status may also be tested when the TMC or a laptop computer prompts a pixel test either remotely or on-site. Ensure that a log file can be created containing a list of defective pixels as transmitted to the TMC or a laptop computer. Ensure that the log file includes the pixel status, module number, column number, and pixel number. Ensure that the pixel status test determines the functional status of the pixel as stuck-on or stuck-off and does not affect the displayed message for more than half a second.

Ensure that LEDs are individually mounted directly on a PCB, and are individually removable and replaceable using conventional electronic repair methods.

**781-3.2.3.3 Optical, Electrical, and Mechanical Specifications for Display Modules:** Ensure that each display module contains connectors for power, controls, and data; contains display module control electronics and memory elements; and provides the signals to switch the LED pixels.

Ensure the display modules are rectangular and have an identical vertical and horizontal center-to-center distance (i.e., pitch) between adjacent pixels ranging from 1.71 inches to 1.82 inches. Ensure that the separation between the last column of one display module and the first column of the next module is equal to the horizontal distance between the columns of a single display module.

Ensure that the LED circuit board is a NEMA FR4-rated, single 0.062-inch, black PCB. Ensure that alternate LED board configurations are submitted to and pre-approved by the Engineer prior to installation. Ensure that PCBs enable components to be removed and replaced without damage to boards, traces, or tracks. Ensure that the intercomponent wiring is a copper-clad track having a minimum weight of 2 ounces per square foot with an adequate cross section for carrying circuit current. Ensure that no PCB has more than two PCB jumper wires present. Finish all PCBs with a solder mask and a component identifying silk screen.

Provide all PCBs, except for the LED motherboard and power supply PCBs, with a complete and conformal coating of silicone or acrylic resin with a minimum thickness of 0.01 inch. Provide the LED motherboards with a complete conformal coating of silicone or acrylic resin with a minimum thickness of 0.01 inch, except for the pixels on the front of the PCB. Meet the material requirements of MIL-I-46058C Military Standard, United States Department of Defense (USDOD).

Mount all LEDs so that the mechanical axis of the LED is ±1 degree to the sign's face to ensure uniformity of brightness over the sign's face. Ensure that LEDs are secured perpendicular to the display module within 0.5 degree and may be easily removed from the display module PCB without tools. Ensure that any devices used to secure LEDs do not block air flow to the LED leads or block the LED light output at the required viewing angle. Ensure that all components on the LED side of PCBs are black.

Ensure that the voltage to the LED modules and their associated electronics does not exceed 25 $V_{DC}$. Ensure that there are a minimum of two, and a maximum of four, power supplies that are wired in a parallel configuration for redundancy. Ensure that multiple power supplies are used to provide power to each display module. Ensure the voltage measured at the display modules does not vary more than 50 millivolts over all the display modules in the sign with 17 pixels on at 100% intensity in each display module. Ensure that if one supply completely fails, the sign shall still be supplied with enough power to run 40% of all pixels at a 100% duty cycle with an ambient operating temperature of 165° F. Ensure that the supplies have a current sharing capability that allows them to provide equal amounts of current to their portion of the LED display.

Ensure that the sign controller continuously measures and monitors all LED module power supply voltages and provides the voltage readings to the

TMC or a laptop computer on command. Ensure that an error message will be sent to the TMC or a laptop computer when it polls the sign controller if voltages measured are outside nominal values.

Ensure that LEDs are protected from external environmental conditions, including moisture, snow, ice, wind, dust, dirt, and UV rays. Do not use hoods, louvers, cylinders or visors that could impede the free flow of air over any surface of each individual LED. Do not use epoxy to encapsulate the LEDs.

**781-3.2.4 Character Displays:** Ensure that the signs are capable of displaying American Standard Code for Information Interchange (ASCII) characters 32 through 126, including all uppercase and lowercase letters and digits 0 through 9, at any location in the message line.

Ensure that the uppercase alphanumeric characters are displayed over the complete height of the matrix. Submit a list of the character fonts to the Engineer for approval.

Characters must be legible under all light conditions at a distance ranging from 100 to 600 feet within the 30-degree cone of vision centered on the pixel's optical axis. Ensure that the operator is able to display compressed, expanded, or double-stroke character fonts, and to change the default spacing between characters. Ensure that the spacing options include 1-, 2-, or 3-pixel columns between the characters. Ensure the system is loaded with a default font in accordance with the Standard Font set described in NEMA TS4-2005 (section 5.6). Ensure the system allows the assignment of font access privileges. Ensure that the sign controller is capable of a self-updating time and/or date display on the sign.

Ensure that the sign controller allows a moving arrow to be displayed on one line with a standard text message on the other lines. Ensure that the moving arrows may be shown moving from the left or right, and starting from one end or in the middle of the sign and continuing to the end of the sign.

**781-3.2.5 Main Power Supply and Energy Distribution Specifications:** Provide a nominal single-phase power line voltage of 120/240 $V_{AC}$ protected by a two-pole (i.e., common trip) main circuit breaker sized as required for the sign and its controller. Ensure that the system operates within a voltage range of 97 to 135 $V_{AC}$ as specified in NEMA TS 4, Subsection 2.1.3.1.

Ensure that all power inside the sign housing is supplied by 120 $V_{AC}$ independently protected by a thermomagnetic circuit breaker at the sign's service entry point. Locate all 120 $V_{AC}$ wiring in conduit, pull boxes, raceways, or control cabinets as required by the NEC. Ensure that no 120 $V_{AC}$ wiring is exposed inside or outside of the sign housing. Do not use the sign housing as a wiring raceway or control cabinet.

Ensure that the sign and its controller have an operating frequency of 60 hertz (Hz), ±3.0Hz, as stated in NEMA TS 4, Subsection 2.1.3.2. Ensure that the drop in the unit's voltage between no-load and full-load during normal operations does not exceed 10% of the nominal voltage. Provide power protection through the use of a thermomagnetic circuit breaker connected to a 5-milliampere GFI device that protects all service outlets. Provide a 100-amp 120/240 $V_{AC}$ two-pole load center with a 20-circuit capability. Provide separate circuit breakers for each sign circuit.

Provide Type XHHW power cables sized as required by the NEC for acceptable voltage drops while supplying alternating current to the sign. Ensure that the sign power consumption does not exceed 3,000 VA under any circumstance, including operation of fans and heaters (if provided within the sign), sign controllers and communication equipment, and all pixels illuminated at 100% brightness.

Provide protection devices such as surge suppressors and lightning arrestors installed or incorporated in the sign system by the manufacturer to guard against lightning, transient voltage surges, and induced current. Ensure that the protection devices meet or exceed the device protection requirements as contained in Section 785-2. Use protection devices on all electric power and data communication connections.

Ensure that the DC and AC voltage ratings and dissipation factors of capacitors used in the sign system exceed the worst-case design parameters of the circuitry by 50%. Ensure that capacitors that are not surface mount components are mechanically supported by a clamp or fastener that is resistant to cracking, peeling, and discoloration.

Ensure that resistors used in the sign are within 5% of the tolerance of the specified temperature range and, when operated in excess of 50% of its power rating, have an adequate heat sink.

Ensure all transistors, integrated circuits, and diodes are a standard type, listed by the EIA, and clearly identifiable.

**781-3.2.6 Uninterruptible Power Supply:** Provide each sign with an uninterruptible power supply (UPS) capable of maintaining and continuing the operation of the sign and its related communication device for a minimum of two hours. Provide sealed AGM type batteries that are maintenance free.

**781-3.2.7 Operational Support Supplies:** Furnish the operational support supplies listed in the table below. Promptly replace any of the supplies used to perform a warranty repair.

For every group of 10 or fewer 12” DMS signs provided or required, provide 1 set of supplies as follows:

| | |
|---|---|
| 1 each | Sign Controller |
| 5 each | LED Display Modules |
| 1 each | Uninterruptible Power Supplies |
| 1 each | System Interface Circuit |
| 1 each | Cable for connecting interface circuits to daughter boards (if applicable) |
| 1 each | Display Module Cables |
| 2 each | Surge Suppression Sets |
| 1 each | Fan Assembly |
| 1 each | Time Relay for Fan Control |
| 10 each | Every Small Fuse (< 10 amp) |
| 2 each | Every Large Fuse (> 10 amp) |
| 1 each | Sensor for each type of sensor |

The Engineer will review and approve the operational support supplies.

**781-3.2.8 Sign Controller:** Ensure that the sign is provided with a sign controller that includes operational firmware stored in nonvolatile memory. Program the controller to receive sign control commands, transmit responses (as requested), and to control sign operation and message displays both remotely and on site to and from designated users. Ensure that sign controller functions include error logging and reporting, and providing the operational status of the sensors including temperature, photocell, airflow, and humidity and LED power supply sensors.

Ensure that the sign controller will read the internal temperature sensors, the external ambient temperature sensors, and the humidity sensors and use the readings in an algorithm that turns on heat tape and/or fans when conditions warrant preventing frost on the face of the sign and condensation on the display modules and other electronic circuitry.

Ensure that the sign controller receives and sends messages by way of an Ethernet network and that the failure of any sign does not affect the operation of any other sign in the system.

Ensure that, at a minimum, the sign controller provides for local control and programming of the sign, including power on/off, communications, and sign diagnostics and error status.

Ensure that the controller provides power-up and automatic restart capabilities with automatic sign blanking when recovering from a power-off condition. Ensure that the sign can be configured to either display a stored message or blank upon recovery from power loss and upon recovery from system resets. Utilize a hardware watchdog circuit to provide automatic recovery from critical errors and automatic shutdown in the event of critical hardware failure.

Mount the sign controller within the sign housing. Ensure that there is a ground level access point at the sign location that allows the sign to be programmed and controlled locally using a laptop computer.

**781-3.2.9 Display System Hardware:** Ensure the sign utilizes a system data interface circuit for communication between the sign controller and display modules. Ensure that the following components reside inside the sign housing: sign controller, display system interface circuits, display modules, power supplies, local and remote control switches, LED indicators, Electronic Industries Alliance (EIA)-232 null modem cables (minimum of 4 feet long for connecting laptop computer to sign controller), and transient voltage surge suppressors.

**781-3.2.10 Control Cabinet Specifications:** Provide a control cabinet that meets the requirements of Section 785-4.

Equip the ground control cabinet with the assemblies and components, as shown in the plans: power indicator, surge suppression on both sides of all electronics, communication interface devices, connection for a laptop computer for local control and programming, cables a minimum of 4 feet long to connect laptop computers, a UPS system, a workspace for a laptop computer, and duplex outlets.

Provide for all telephone, data, control, power, and confirmation connections between the sign and ground control box, and for any required wiring harnesses and connectors.

**781-3.2.11 Sign Controller Communication Interface:** Ensure that the sign controller includes two separate EIA-232 serial interfaces inside the sign housing for

communication with the TMC or a laptop computer, and one Ethernet 10/100 Base TX 8P8C port. Ensure that EIA-232 serial interfaces support the following:

Data Bits: 7 or 8 bits
Parity: Even, Odd, None, Mark, or Spare
Number Stop Bits: 1 or 2 bit

Ensure that all Category 5 unshielded twisted pair/shielded twisted pair network cables are compliant with the EIA/TIA-568-A standard.

Configure one EIA-232 serial interface to drive asynchronous modems for full duplex communication with the TMC over point-to-point dial-up lines or a multidrop fiber or copper network. Ensure that switching between dial-up, Ethernet, and multidrop operation does not require sign controller software or hardware modifications.

For dial-up operations, acquire and bear the charges of installing and connecting the dial-up telephone line. Provide modems to be retained by the Department at each location. Provide user selectable data transmission rates of up to 56 kbps for dial-up operations.

Configure the second EIA-232 serial port for local communication with a laptop computer.

Ensure that the sign controller can be managed remotely from a TMC or locally using a laptop computer. Ensure that the TMC or a laptop computer can be used to remotely reset the sign controller.

Ensure that the sign controller and its software will display single-page and multi-page messages with mixed fonts and spacing. Ensure that message page times and text flashing rates are programmable between 0.5 and 5 seconds in 0.1-second increments.

Ensure that the sign system will log and report errors and failures, including data transmission errors, receipt of invalid data, communication failure recoveries, alternating current power failures, power recoveries, pixel status reads, fan and filter airflow status, temperature status, power supply status, and information on the operational status of the temperature, photocell, airflow, humidity, and LED power supply sensors. Ensure that airflow and humidity sensor information is reported using the objects from the dmsClimateCtrlStatusTable of the NTCIP 1203 V2 standard.

**781-3.2.12 Message and Status Monitoring:** Ensure that the 12” DMS provides two modes of operation: (1) master operation, where the TMC commands and controls the sign and determines the appropriate message or test pattern; and (2) local operation, where the sign controller or a laptop computer commands and controls the sign and determines the appropriate message or test pattern.

Ensure that the sign can perform the following functions:

1. Control Selection – Ensure that local or remote sign control can be selected. Ensure that there is a visual indicator on the controller that identifies whether the sign is under local or remote control. Ensure that the sign responds to remote control by default. If the sign includes a physical local/remote mode switch, the operating mode must be determined by the position of the mode switch on the local control panel. If the local control panel’s switch is set to local, the operating mode is local. Otherwise, the operating mode is master.

2. Message Selection – Ensure that the sign controller can select a blank message or any one of the messages stored in the sign controller’s nonvolatile memory when the control mode is set to local.

3. Message Implementation – Ensure that the sign controller can activate the selected message.

Ensure that the sign controller transmits a return message to the TMC whenever it receives a valid status request. Ensure that return messages contain an Internet Protocol (IP) address for the sign controller, the actual message that is visibly displayed on the sign, the displayed message's transmission origin (i.e., the TMC, laptop computer, manual entry, etc.), remote or local control status, error and failure reports, temperature readings, access alarms, power supply voltage levels, line voltage, and UPS status.

In the event of a sign controller failure, ensure that the sign controller blanks any message displayed. Ensure that the sign can be programmed to display a user-defined message, including a blank page, in the event of power loss.

Ensure that message additions, deletions, and sign controller changes may be made from either the remote TMC or a local laptop computer. Ensure that each font may be customized, and modifications to a font may be downloaded to the sign controller from the TMC or a laptop computer at any time without any software or hardware modifications. Ensure the sign is capable of displaying a different font and character spacing on each line.

Ensure that messages can be activated with a run-time duration specified. Ensure that the sign can be programmed to display a user-defined message, including a blank page, once the run-time duration of another message has expired. Ensure that there is no perceivable flicker or ghosting of the pixels during sign erasure and writing periods.

Ensure that in the event of an AC power loss all nonvolatile memory is retained for a minimum of 30 calendar days. Ensure that the sign controller monitors the messages downloaded from the TMC or laptop computer to make sure that the message will fit in the display area of the sign. Ensure that the sign controller's internal time clock provides for message deactivation at the correct time, even in the event of a communication loss. Ensure that the sign controller maintains its internal clock during power outages and automatically displays the proper message when power is restored within 255 minutes. Ensure that the sign can also be programmed to automatically blank the display following a power outage longer than 255 minutes.

**781-3.3 TMC Communication Specifications for all DMS:** Ensure that the sign controller is addressable by the TMC through the Ethernet communication network using software that complies with the NTCIP 1101 base standard (formerly the NEMA TS 3.2 - 1996 standard), including all amendments as published at the time of contract letting, and the NTCIP Simple Transportation Management Framework, and conforms to Compliance Level 1. Ensure that the software implements all mandatory objects as defined in the FDOT standard Global MIB in Appendix A, all mandatory objects as defined in the FDOT-standard DMS MIB in Appendix B, and all mandatory objects as defined in the FDOT-specific DMS MIB in Appendix C as published online at http://www.dot.state.fl.us/trafficoperations/APL/fdot_dms_info.shtm at the time of contract letting. Ensure that the sign complies with the NTCIP 1201 v01, 1203 v01, 2101 v01.19, 2103 v01.13, 2201 v01.14, 2202 v01.05, and 2301 v01.08 standards. Ensure that compliance with FDOT MIB requirements takes precedence within NTCIP

implementations. Ensure that any additional objects implemented by the software do not interfere with the standard operation of any mandatory objects.

Ensure that each sign provides full, standardized range support for all objects required by these specifications unless otherwise detailed in the plans. The standardized range is defined by a size, range or enumerated listing indicated in the object's syntax field and/or through descriptive text in the relevant standard object description field. Ensure that the sign maximum response time for any object or group of objects is 200 milliseconds unless otherwise indicated in the plans, or unless approved by the FDOT Traffic Engineering Research Laboratory (TERL). Deviances from the full ranges for objects are detailed in Table 1.

| Table 1 – Range Deviances for Objects | |
|---|---|
| Object | Minimum Project Requirements |
| FDOT Global MIB v01c | |
| Maximum Event Log Configurations | 50 |
| Event Configuration Mode | 2, 3, and 4 |
| Maximum Event Log Size | 200 |
| Maximum Event Classes | 7 |
| Maximum Group Address | 1 |
| FDOT DMS MIB v01c | |
| Number of Fonts | 4 |
| Maximum Font Characters | 255 |
| Default Background Color | 0 |
| Default Foreground Color | 9 |
| Default Justification Line | 2, 3, 4 |
| Default Justification Page | 2, 3, 4 |
| DMS – Number of Permanent Messages | 0 |
| DMS – Maximum Changeable Messages | 50 |
| DMS – Maximum Volatile Messages | 0 |
| Nonvolatile Memory | 5 KB |
| DMS – Control Mode | 2, 3, 4, and 5 |
| Number of Action Table Entries | 15 |
| Number of Brightness Levels | 255 |

Ensure that the software implements the tags (opening and closing where defined) of MULTI as detailed in Table 2 and as defined in the NTCIP 1203 standard.

| **Table 2 – NTCIP 1203 Standard Software Tags** * | | |
|---|---|---|
| Opening Tag | Closing Tag | Explanation |
| cbx | | Color – Background – The background color for a message. |
| cfx | | Color – Foreground – The foreground color for a message. |
| fx,y | | Field – The information to embed within a message that is based on data from some device, such as a clock, calendar, temperature sensor, detector, etc. |

| | | |
|---|---|---|
| | | The following field tag values (IDs) are REQUIRED to be supported:<br>1 – the time in a 12-hour format;<br>2 – the time in a 24-hour format;<br>4 – the ambient temperature in degrees Fahrenheit;<br>7 – the day of the week;<br>8 – the date of the month;<br>9 – the month of the year;<br>10 – the year in two digits; and<br>11 – the year in four digits. |
| fltxoy | /fl | Flash – Activate flashing of the text; define the flash-on and flash-off times; and the flash order (i.e., on/off or off/on). |
| fox | | Font – Select a font number (as specified in the font table) for the message display. |
| jlx | | Justification – Line – Specify line justification: left, center, right, or full. However, full justification is not required. |
| jpx | | Justification – Page –Specify page justification: top, middle, or bottom. |
| mvtdw,s,r,text | | Moving – Text – Specify the parameters of a horizontal moving (scrolling) text. |
| nlx | | New – Line – Specify the start of a new line. |
| np | | New – Page – Specify the start of a new page. |
| ptxoy | | Page – Time – Specify the page times (t = on, o = off). |
| scx | /sc | Spacing – Character – Specify the spacing between characters. |
| * The letters "x" and "y" are character placeholders, usually for numbers, that specify the tag parameter(s). See the NTCIP 1203 standard and its amendments for further definitions. | | |

Provide each sign controller with error detection and reporting features that will be used to guard against incomplete or inaccurate transmissions including cyclic redundancy checking of all data received from the TMC, with positive acknowledgment for all valid transmissions; status monitoring for communication line malfunctions or breakages; and content validation for all transmissions received for logic or data errors.

Provide communication line circuits that are point-to-point or multipoint, and that provide full duplex asynchronous data transmissions at the rate shown in the contract documents or directed by the Engineer.

Assign each sign controller a unique address. Where applicable, encode all data transmitted between the TMC and the sign controller using 1 start bit, 8 data bits, and 1 stop bit.

**781-3.4 Electronic Components:** Ensure that all electronic components, with the exception of PCBs, are commercially available, easily accessible and replaceable, and individually removable using conventional electronic repair methods.

Ensure that all workmanship complies with the ANSI International Policy Committee (IPC) requirements as defined in the ANSI/IPC-A-610B, ANSI/IPC-7711, and ANSI/IPC-7721 Standards.

**781-3.5 Mechanical Components:** Ensure that the sign is fabricated using only stainless steel external screws, nuts, and locking washers. Do not use self-tapping screws

unless specifically approved by the Engineer. Ensure that all parts are fabricated from corrosion-resistant materials, such as plastic, stainless steel, aluminum, or brass. Ensure that construction materials are resistant to fungus growth and moisture deterioration. Ensure that all dissimilar metals are separated with an inert, dielectric material.

**781-3.6 Sign Control Software:** Ensure that the sign is provided with computer software from its manufacturer that allows an operator to program, operate, exercise, diagnose, and read current status of all sign features and functions using a laptop computer. Ensure that sign control software provides a graphical representation that visibly depicts the sign face and the current ON/OFF state of all pixels as well as allows messages to be created and displayed on the sign. Ensure that the laptop computer and sign can communicate when connected directly by an EIA-232 cable and via Ethernet. Ensure that the laptop computer and sign can communicate across the ITS system's communication network using the NTCIP standards described in this document. Ensure that the software will allow communication between multiple users and multiple signs across the same communication network.

**781-3.7 Sign Support Structure:** Meet the requirements of 700-2.4.

**781-3.8 Installation Requirements:** Do not install the sign prior to the availability of electric power. Verify that any ventilation system incorporated within the sign is operational within 72 hours after sign installation.

Set the sign housing's vertical angular alignment as shown in the plans. Ensure that lifting eyebolts are removed and any remaining holes in the top surface of the sign are sealed to prevent water entry after installation.

Load the initial message libraries on both the sign control software and the sign controller. The Engineer will furnish the messages to be placed in these libraries.

**781-3.9 Documentation:** Provide documentation as noted below, reflecting the as-built conditions necessary to facilitate the operation, maintenance, modification, and expansion of the DMS system or any of its individual components. Manufacturer-supplied documentation that covers the intent of these specifications may be used, subject to the approval of the Engineer.

Provide the Engineer with two paper copies and one electronic copy of all documentation. Print the paper copies on 8 1/2-by-11-inch paper and place in three-ring binders. Format the electronic copy in portable document format and submit on CD-ROM. Ensure that electronic submittals are compatible with the Department's own software and CADD programs at the time submittals are made. In addition, place one paper copy of an operations and maintenance manual and as-built drawings, wiring diagrams, and schematics at each DMS location. Ensure that the drawings are printed on 11-by-17-inch sheets and include structural member and attachment support details. Provide each of the following items in the operations and maintenance manual:

1. A general description of the equipment's basic use and function. Provide a general block diagram of the DMS equipment, including the nomenclature, physical and electrical characteristics, and the functions of any auxiliary devices utilized.

2. Sections describing the DMS using block diagrams and schematic drawings. Furnish layout drawings showing the location of all components, along with a complete components list. Use a logical development starting with a system block level and proceeding to a circuit analysis. Detail the circuit analysis whenever circuits are not normally found in standard textbooks. Fully describe the application of

new theoretical concepts. Where the design allows operation in a number of different modes, provide an operational description of each mode.

3. The standard routine of operation for the DMS, from necessary preparations for placing the equipment into operation to securing the equipment after the beginning of operation. Include appropriate illustrations with the sequence of operations presented in tabular form wherever feasible. Provide a list of applicable test instruments, aids, and tools required in the performance of necessary measurements and techniques for each system component. Describe setup tests and calibration procedures.

4. Information required to maintain, diagnose, and repair the sign and its controller to the component level, including the manufacturer's recommended procedures for preventive maintenance performed weekly, monthly, quarterly, semi-annually, and annually, and any other required maintenance checks necessary to assure reliable equipment operation. Fully describe all adjustments and alignment procedures and provide descriptions of expected signals at all test points and outputs. List all requirements, including tolerances for all electrical, mechanical, and other applicable measurements and adjustments. Provide a repair and troubleshooting decision tree that describes each function, the tests of each function, and any process that defines faulty elements that require repair, replacement, or adjustment to restore operation of a malfunctioning sign or system element.

5. General instructions for the disassembly, overhaul, and reassembly of the DMS, including shop specifications and operating performance specifications.

6. Detailed instructions and specifications for maintenance that must be accomplished by specialized technicians and engineers in a modern electromechanical shop. Include instructions that describe special test setups, component fabrications, and the use of special tools, jigs, and test equipment.

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

8. A parts list containing all equipment within a group, and a list of all assemblies, subassemblies, and unit replacement parts. Arrange the list in alphanumerical order of the schematic reference symbols and shall give the associated description, manufacturer's name, and part number. Provide a table of contents or some other appropriate grouping method for the purpose of identifying major components, assemblies, etc.

9. Complete and accurate schematic diagrams as required to supplement the text material and to allow the books to be self-contained technical information sources. Include part reference symbols, test voltages, waveforms, and other aids to understanding the circuit's functions on the diagrams.

Include drawings of conduit layouts, cable diagrams, wiring lists, control cabinet layouts, wiring diagrams, and schematics for all elements of the communication system in the final documentation. Include detailed drawings identifying the routing of all conductor pairs in the communication system by cable type, color code, and function. Upon completion of the installation, submit these plans, maps, drawings, and/or diagrams to reflect an as-built condition, incorporating all changes made during installation, such as in-pair identification and routing.

Provide software and documentation for the TMC software system and its components including, but not limited to all documentation concerning the sign controller communication protocol, including information needed to define the interface design, software codes, message definitions, and message sequences for DMS control and feedback; and one complete copy of the manufacturer's documentation for plug-in circuit cards used in the microcomputer chassis.

Provide documentation that reflects all field changes and software modifications and revisions prior to the power-on test period for the DMS. Modify the documentation with any final corrections or adjustments made during the test period. Submit the documentation to the Engineer within seven days of the successful completion of the operational testing.

**781-3.10 Licensing:** Ensure that the manufacturer grants the Department a nonexclusive, unrestricted license that allows the Department to use, modify, and/or distribute any and all of the stated communication protocols, sign operating systems, drivers, and documentation.

**781-3.11 Technical Assistance:** Ensure that a manufacturer's representative is available (preferably on site) to assist the Contractor's technical personnel at each sign installation site for sign-to-sign structure installation, sign controller cabinet installation, and sign-to-controller cabling.

Do not proceed with the initial powering up of the sign(s) without the permission of the manufacturer's representative.

**781-3.12 Testing:** Conduct performance testing of materials and equipment not previously tested and approved. If the technical data is not considered adequate for approval, samples may be requested for testing by the Engineer. The contract period will not be extended for time lost or delays caused by testing prior to the Engineer's final approval of any items.

Subject the equipment covered by these specifications to design approval tests (DATs) and factory demonstration tests (FDTs). The Engineer may accept certification by an independent testing laboratory in lieu of the DATs to verify that the tests have been previously completed satisfactorily. Arrange and conduct the tests in accordance with the testing specifications stated in this section. Unless otherwise specified, the Contractor is responsible for satisfying all inspection requirements prior to submission for the Engineer's inspection and acceptance.

The Engineer reserves the right to witness all DATs and FDTs. The tests on all or one type of equipment must be completed within five calendar days. The Contractor shall be financially responsible for testing each DMS.

Provide five copies of all design approvals, FDTs, stand-alone and subsystem test procedures, and data forms for the Engineer's approval at least 60 calendar days prior to the beginning of testing. Include in the test procedures the sequence in which the tests will be conducted. Obtain the Engineer's approval of the test procedures prior to testing the equipment.

Furnish data forms, certified and signed by the manufacturer, containing all of the data taken, and the quantitative results for all tests. Send one copy of the data forms to the Engineer.

Provide the test fixtures and test instruments for all the tests.

**781-3.12.1 Design Approval and Preshipment Factory Demonstration Testing:** Conduct DATs on one or more samples of each type of equipment, as approved by the Engineer, to determine whether the equipment design meets project requirements. Conduct the test in accordance with the approved test procedures as described in this section. All requirements listed herein take precedence over the applicable NEMA TS 4 standard.

**781-3.12.1.1 Temperature and Condensation:** Provide results of the FDTs to the Engineer or his representative prior to shipment. Test requirements include the following:

1. Stabilize the equipment at -29°F. After temperature stabilization, operate the equipment without degradation for two hours.
2. Cause moisture to condense on the equipment by allowing it to warm to room temperature in an atmosphere having a relative humidity of at least 40% and satisfactorily operate the equipment for two hours while wet.
3. Stabilize the equipment at 165°F. After stabilization, satisfactorily operate the equipment for two hours without degradation or failure.

**781-3.12.1.2 Primary Power Variation:** The equipment shall meet the defined performance specifications when the nominal input voltage is 120 volts, ±11.5 volts. Operate the equipment at extreme limits for at least 15 minutes, successfully performing FDTs.

**781-3.12.1.3 Relative Humidity:** The equipment shall meet its performance specifications when subjected to an ambient operating temperature of 165°F and a relative humidity of 90%. Maintain the equipment at the above condition for 48 hours. At the conclusion of the 48 hour soak, the equipment shall meet FDT requirements within 30 minutes of beginning the test.

**781-3.12.1.4 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 required in Section 2.2.5 of the NEMA TS 4 standard.

**781-3.12.1.5 Water Spray Hose Test:** Test the fully assembled DMS by way of a directed water spray hose test. The test shall consist of a 10-minute soaking of the DMS by way of two constant streams of water. The water spray shall be delivered by two hoses, 0.625 inch in diameter, with a water throughput of 6 gallons per minute at 45 pounds per square inch. One hose with a medium spray nozzle shall be directed at the sign face. The hose setup for the sign face shall be placed 15 feet from the sign face, be 12 feet in height, and be set at a 45-degree down angle. The second hose with a heavy spray nozzle shall be directed at the top of the sign cabinet in the form of heavy spray. This top hose setup shall be set at 10 feet directly above the sign cabinet pointing directly down on top of the cabinet. The water shall run continuously for 10 minutes. At the end of the test period, the interior of the sign shall be inspected for leaks, water/moisture contamination of the electronics, standing water in the base of the sign, and any other abnormal water/moisture issues. Note any leaks and have them permanently repaired. Retest until all leaks are stopped. Note all repairs on the as-built documentation.

**781-3.12.2 Preshipment Factory Demonstration Testing:** Conduct FDTs on all units at a Contractor-provided facility. Notify the Engineer a minimum of 30 calendar days before the start of tests. Conduct all tests in accordance with the approved test procedure contained in this section. All equipment shall have passed the following individual tests.

**781-3.12.2.1 Product Examination Test:** Examine each piece of equipment carefully to verify that the materials, design, construction, markings, and workmanship comply with the requirements of these specifications.

**781-3.12.2.2 Continuity Test:** Check the wiring to determine conformance with the requirements of the appropriate paragraphs in these specifications.

**781-3.12.2.3 Operational Test:** Operate each piece of equipment long enough to permit equipment temperature stabilization, and to check and record an adequate number of performance characteristics to ensure compliance with the requirements of these specifications.

Have factory personnel make necessary changes and repairs, making notations of the repairs on the as-built documentation. Retest to verify the proper operation of the repaired components. Upon satisfactory completion of all pre-shipment testing, the Engineer will release the sign for shipment.

If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the Department and/or without an extension of the contract period.

**781-3.12.3 Pre-installation Field Testing:** Conduct pre-installation tests on all units at a Contractor-provided facility within the appropriate District. Perform the tests on each unit supplied to verify that no damage was done to any sign during the shipment and delivery process. Notify the Engineer a minimum of 10 calendar days before the start of any tests. Conduct all tests according to the approved test procedures detailed in this section. Each DMS must pass the individual tests detailed below prior to installation.

**781-3.12.3.1 Product Examination Test:** Examine each DMS carefully to verify that the materials, design, construction, markings, and workmanship comply with all applicable standards, specifications, and requirements.

**781-3.12.3.2 Continuity Test Specifications:** Check the wiring to determine conformance with the applicable standards, specifications, and requirements.

**781-3.12.3.3 Operational Test Specifications:** Operate each DMS long enough to permit equipment temperature stabilization, and to check and record an adequate number of performance characteristics to ensure compliance with applicable standards, specifications, and requirements.

**781-3.12.3.4 Pre-installation Test Failure Consequence:** If any unit fails to pass an FDT, 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 an FDT failure, a report shall be prepared and delivered to the Engineer prior to the unit's shipment. 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 Department or an extension of the contract period.

**781-3.12.4 Installed Site Tests:** Conduct an approved, stand-alone equipment installation test at the field site. Test all stand-alone (i.e., non-network) functions of the field equipment using equipment installed as detailed in the plans, and as approved by the Engineer.

Complete approved data forms and turn them over to the Engineer for review, and as a basis for rejection or acceptance. Provide a minimum notice of 30 calendar days prior to all tests to permit the Engineer or his representative to observe each test.

If any unit fails to pass its stand-alone test, correct the unit or substitute another unit in its place, then repeat the test.

If a unit has been modified as a result of a stand-alone test failure, prepare a report describing the nature of the failure and the corrective action taken and deliver it to the Engineer prior to re-testing the unit. If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the Department or an extension of the contract period.

**781-3.12.5 System Testing:** Conduct approved DMS system tests on the field equipment with the master equipment including, at a minimum, all remote control functions. Display the return status codes from the sign controller for a minimum of 72 hours. Complete approved data forms and turn them over to the Engineer for review, and as a basis for rejection or acceptance.

Demonstrate the sign's ability to display the proper predefined message or remain blank when power is restored following an AC power interruption.

If the system test fails because of any subsystem component, repair that component or substitute another in its place, then repeat the test. If a component has been modified as a result of a system test failure, prepare a report and deliver it to the Engineer prior to retesting.

**781-3.12.6 Operational Testing:** After the ADMS system installation and system testing are successfully completed, conduct one continuous 72-hour, full-operating test prior to conducting the 60-day Acceptance Test. The Engineer will approve the type of tests to be conducted. Include in the tests all control, monitoring, and communication functions of the field equipment by the master equipment.

**781-3.12.7 Acceptance Testing:** Commence the 60-day test period on the first day after the successful completion of the approved 72-hour Operational test. During the 60-day test period, limit downtime due to mechanical, electrical, or other malfunctions to a maximum total of 5 calendar days. If the equipment fails to operate for a total of five or more calendar days, testing will be restarted. The Engineer may select to pause and extend the 60-day test period by the number of days lost by failure and repair time in lieu of restarting the full 60-day test. The Engineer will furnish the Contractor with a letter of approval and completion stating the first and last day of the 60-day test period.