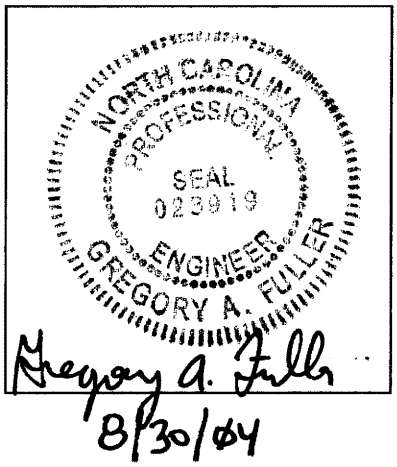

Project Special Provisions

Traffic Management Systems

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26-Aug-04

Contents

1. 2002 STANDARD SPECIFICATIONS FOR ROADS & STRUCTURES – SECTION 1098 REVISIONS

The 2002 Standard Specifications are revised as follows:

1.1 General Requirements (1098-1)

Page 10-220, Subarticle 1098-1(A)

In the last paragraph, sentence 1, revise "by the date of advertisement of the project" to "by the date of equipment installation."

1.2 Wood Poles (1098-6)

Page 10-228, Article 1098-6

Replace the entire article with the following:

Provide poles of treated southern pine or treated Douglas fir that meet the requirements of ANSI 05.1. Provide Class 3 or better wood poles that are a minimum length of 40 feet (12.2 meters) unless otherwise shown on the plans and are of a sufficient length to maintain minimum required distances above the roadway, obstructions and affected railroad tracks. Mark each pole in accordance with ANSI 05.01. First roof and bore poles and then give them a full-length preservative treatment.

Provide poles with pentachlorophenol or chromated copper arsenate (CCA) preservative, in accordance with AWPA Standard C4-99. Ensure the retention of preservative is a minimum of 0.45 lb. per cubic foot (7.2 kg per cubic meter) for pentachlorophenol and 0.6 lb. per cubic foot (9.6 kg per cubic meter) for CCA.

1.3 Metal Poles (1098-15)

Page 10-236, Subarticle 1098-15(A)

In paragraph 1, sentence 2, delete the phrase "(AASHTO Specifications) in effect on the date of advertisement" and insert the words "Fourth Edition, 2001, including the latest interim specifications."

Page 10-238, Subarticle 1098-15(B)

In paragraph 1 (partial), sentence 2, delete the phrase "6 x 6 x 3/4 inches (150 x 150 x 18 mm)" and insert the words "circular anchor bolt lock."

In the first full paragraph, add the following sentence:

Where splicing is necessary, use butt splice and heat shrink tubing.

2. 2002 STANDARD SPECIFICATIONS FOR ROADS & STRUCTURES – SECTION 1700 REVISIONS

The 2002 Standard Specifications are revised as follows:

2.1 General Requirements (1700)

Page 17-3, Subarticle 1700-3 (J)

In paragraph 2, sentence 2, revise "detectable metallic burial tape" to "marker tape."

2.2 Underground Conduit (1715)

Page 17-8, Subarticle 1715-3(A)

Add the following paragraph:

Install metallic conduit at all locations where conduits traverse railroad tracks or as shown on the plans. For all other locations, install nonmetallic conduit unless otherwise shown on the plans. Backfill with excavated material and compact to 95% of its original density. Remove any rock and debris from backfill material.

Page 17-8, Subarticle 1715-3(C)

Delete the first paragraph.

Page 17-8, Subarticle 1715-3(D)

Replace reference to Article 342-3 with reference to Article 1540-3 (A&B).

2.3 Wood Poles (1720)

Page 17-10, Article 1720-3

Replace the fourth paragraph with the following paragraph:

On joint use poles and NCDOT-owned poles, at signal and traffic management systems equipment installations (i.e. controller cabinets, CCTV cabinets, DMS cabinets, etc.), bond the messenger cable(s) to the existing pole ground using Burndy clamps at each end and at 1300-foot intervals. On multiple messenger cable arrangements, connect all messenger cable ends with #6 solid bare copper wire and bond with split bolt connectors or Burndy clamps (UCG25RS) or equivalent. On joint use and NCDOT-owned poles, if an existing pole ground does not exist, install a grounding system consisting of a #6 AWG bare copper wire that is exothermically welded to a ground rod.

In the last paragraph, last sentence, revise "5/8 inch x 8 foot (16 mm x 2.4 m) ground rod" to "5/8 inch x 10 foot (16 mm x 3.0 m) ground rod."

2.4 Structure Design of Signal Supports (1744)

Page 17-26-28, Subarticle 1744-2(A)

In paragraph 2, sentence 2, delete the phrase "(AASHTO specifications) in effect on the date of advertisement" and insert the words "Fourth Edition, 2001, including the latest interim specifications." Revise "with a 1.3 gust factor" to "with a minimum 1.14 gust factor."

Add the following paragraph after paragraph 2:

"Use the following in design, which is taken from The Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 4th Edition, 2001:

- The wind pressure map that is developed from the 3-second gust speeds, as provided in Article 3.8, shall be used.
- Signal support structures shall include natural wind gust loading and truck-induced gust loading in the fatigue design, as provided for in Article 11.7.3 and 11.7.4, respectively. Designs need not consider periodic galloping forces.
- The natural wind gust speed in North Carolina is assumed to be 11.2 mph.
- The fatigue importance category used in the design, for each type of structure, as provided for in Article 11.6, Fatigue Importance Factors, shall be Category II unless otherwise shown on the contract plans.
- Deflection induced by truck gust, as provided in Article 11.8, at the free end of single-arm sign supports and all traffic signal arms, shall be limited to 8 inches (200 mm) vertically, when the equivalent static design wind effect from truck-induced gusts are applied to the structure.
- Conform to article 10.4.2 of the 2001 AASHTO Specification

The maximum allowable vertical deflection at the tip of the mast arm due to the combined deflection of the pole and the arm shall not exceed 3.0% of the total mast arm length under maximum dead loading conditions.

For span wire mounted signal support structures, wind loads shall be applied as shown in Figure 3-5 of the AASHTO Specification. For Group III loading, where ice is present, half wind shall also be applied to the span wire cable bundle diameter shown above as well as to the increased diameter of the cable bundle due to the presence of ice around the full perimeter of the cable bundle."

"Use the following in design, which modifies The Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 4th Edition, 2001":

Revise Article 11.7.4, Truck-Induced Gust, Equation 11-6 to read as follows:

$$P_{TG} = 900 C_d I_F \quad \text{(Pa)}$$

$$P_{TG} = 18.8 C_d I_F \quad \text{(psf)}$$

Revise the third sentence of Article 11.7.4, Truck-Induced Gust, to read as follows:

"The pressure range shall be applied along any 12 feet (3.7 m) length to create the maximum stress range, excluding any portion of the structure not located directly above a traffic lane."

In Article 11.7.4, Truck-Induced Gust, after the first paragraph, add a paragraph to read as follows:

"The magnitude of applied pressure range may be varied depending on the height of the horizontal support and the attachments above the traffic lane. Full pressure shall

be applied for heights up to and including 19.7 ft (6 m), and then the pressure may be linearly reduced for heights above 19.7 ft (6 m) to a value of zero at 32.8 ft (10 m)."

Revise the third paragraph of the Commentary to Article 11.7.4, Truck-Induced Gust, to remove the following two sentences in their entirety:

"To improve fuel economy ... created by the trailer. It has been proposed ... (Desantis and Haig, 1996)."

Revise the fourth paragraph of the Commentary to Article 11.7.4, Truck-Induced Gust, to read as follows:

"The design pressure calculated from Equation 11-6 is based on a truck speed of 65 mph (30 m/s). For structures installed at locations where the posted speed limit is much less than 65 mph (30 m/s), the design pressure may be recalculated based on this lower truck speed. The following may be used:

$P_{TG} = 900C_d(V/30\ m/s)^2I_F$ (Pa) Eq. C 11-6

$P_{TG} = 18.8C_d(V/65\ mph)^2I_F$ (psf)

Where V is the truck speed in m/s (mph), V may be taken as either the posted speed limit or the design speed (if known), whichever is higher."

Revise the Commentary to Article 11.7.4, Truck-Induced Gust, to remove in their entirety, the fifth and seventh paragraphs, which deal with the application length, and variability of truck gust pressure range.

Page 17-29, Subarticle 1744-2(B)

In the third paragraph, second sentence, revise the phrase "3 percent" to "2.5 percent."

In the fourth paragraph, following the first sentence, add the following:

"The base plate thickness for all uprights and poles shall be no less than that determined by the following criteria and design:

Case 1 Circular or rectangular solid base plate with the upright pole welded to the top surface of base plate with full penetration butt weld, and where no stiffeners are provided. A base plate with a small center hole, which is less than 1/3 of the upright diameter, and located concentrically with the upright pole, may be considered as a solid base plate.

The magnitude of bending moment in the base plate, induced by the anchoring force of each anchor bolt shall be $M = (P \times D_l) / 2$, where:

M = bending moment at the critical section of the base plate induced by one anchor bolt

P = anchoring force of each anchor bolt

D_l = horizontal distance between the center of the anchor bolt and the outer face of the upright, or the difference between the radius of the bolt circle and the outside radius of the upright

The critical section shall be located at the face of the anchor bolt and perpendicular to the radius of the bolt circle. The overlapped part of two adjacent critical sections shall be considered ineffective.

Case 2 Circular or rectangular base plate with the upright pole socketed into and attached to the base plate with two lines of fillet weld, and where no stiffeners are provided, or any base plate with a center hole that is larger in diameter than 1/3 of the upright diameter

The magnitude of bending moment induced by the anchoring force of each anchor bolt shall be $M = P \times D_2$, where:

P = anchoring force of each anchor bolt

D_2 = horizontal distance between the face of the upright and the face of the anchor bolt nut

The critical section shall be located at the face of the anchor bolt top nut and perpendicular to the radius of the bolt circle. The overlapped part of two adjacent critical sections shall be considered ineffective.

The thickness of base plate of Case 2 shall not be less than that calculated based on formula for Case 1."

Page 17-30, Subarticle 1744-2(C)

Delete paragraphs 1 and 2.

3. GENERAL REQUIREMENTS

3.1 DESCRIPTION

A. General

Conform to these Project Special Provisions, Signing Plans, and the *2002 Standard Specifications for Roads and Structures* (also referred to hereinafter as the "Standard Specifications"). The current edition of these specifications and publications in effect on the date of advertisement shall apply.

Conform to the requirements of the pay items included in these Project Special Provisions. All other pay items not described in these Project Special Provisions are included in the Standard Specifications and must be conformed to as described in those specifications unless modified herein. In the event of a conflict between these Project Special Provisions and Standard Specifications, these Project Special Provisions shall govern.

Append the following to Article 1700-1 of the Standard Specifications:

The limits of the R-2237B project for the work described herein is as follows:

- US 321 from SR 1370, Kirby Road to SR 1500, Blackburry Road.

This project is in English units.

Furnish, install, test, integrate and make fully operational Dynamic Message Signs (DMS) and dial-up telephone circuits in order to monitor and control messages from the Division 11 office.

Furnish, install, test, integrate and make fully operational two (2) new DMSs at locations as shown on the Signing Plans.

Append the following to Article 1098-1(G) of the Standard Specifications:

Provide real world coordinates for all field devices (including but not limited to controller cabinets and dynamic message signs) installed and/or modified under this project. Provide the coordinates in feet units using the North Carolina State Plane coordinate system (1983 North American Datum also known as NAD '83). Furnish coordinates that do not deviate more than 1.7 feet (½ meter) in the horizontal plane and 3.3 feet (1 meter) in the vertical plane. Global positioning system (GPS) equipment able to obtain the coordinate data within these tolerances may be used. Submit cut sheets on the GPS unit proposed to collect the data for approval by the Engineer. For equipment cabinets, obtain and provide the location of the cabinet.

Provide both a digital copy and hard copy of all information regarding the location (including to but not limited to manufacturer, model number, and NCDOT inventory number) in the Microsoft spreadsheet provided by the Department, shown by example below.

NCDOT Inv #	Name	Location	Latitude	Longitude	Manufacturer	Model #	Comm Media	Destination
05-7009	Cam 1	I-540/I-40	-78.8123	35.8625	Pelco	Spectravision	60 SMFO	TRTMC
05-7010	Cam 2	NC 54/I-40	-78.7631	35.8523	Pelco	Spectravision	60 SMFO	TRTMC
05-7030	HAR 1 – Johnston Co.	I-40 at NC 42 (mp 312)	-77.952	35.2456			Dial-up	TRTMC
05-7001	DMS # 1	I-85 N/I-40 E, mp 159.1			Mark IV		Dial-Up	TRTMC
05-7003	DMS # 3	I-40 W, mp 307.7			Mark IV		Dial-Up	TRTMC
05-7004	DMS # 4	I-40 E, mp 286.0			Mark IV		60 SMFO	TRTMC

B. Domestic Steel and Iron Products

All steel and iron products which are permanently incorporated into this project shall be produced in the United States except minimal amounts of foreign steel and iron products may be used provided the combined project cost of the bid items involved does not exceed one tenth of one percent (0.1 percent) of the total amount bid for the entire project or $2,500.00, whichever is greater. This minimal amount of foreign produced steel and iron products permitted for use by this Special Provision is not applicable to fasteners. Domestically produced fasteners are required for this project.

All steel and iron products furnished as "domestic products" shall be melted, cast, formed, shaped, drawn, extruded, forged, fabricated, produced, or otherwise processed and manufactured in the United States. Raw materials including pig iron and processed pelletized and reduced iron ore used in manufacturing "domestic" steel products may be imported; however, all manufacturing processes to produce the products, including coatings, must occur in the United States.

Before each steel or iron product is incorporated into this project or included for partial payment on a monthly estimate, the Contractor shall furnish the Resident Engineer a notarized certification certifying that the product conforms to the above requirements of this Special Provision. The Resident Engineer will forward a copy of each certification to the Materials and Tests Unit.

Each purchase order issued by the Contractor or a subcontractor for steel and iron products to be permanently incorporated into this project shall contain in bold print a statement advising the supplier that all manufacturing processes to produce the steel or iron shall have occurred in the United States. The Contractor and all affected subcontractors shall maintain a separate file for steel products permanently incorporated into this project so that verification of the Contractor's efforts to purchase "domestic" steel and iron products can readily be verified by an authorized representative of the Department or the Federal Highway Administration.

3.2 TRAFFIC CONTROL

The two DMSs on US321 shall be installed and made operational during the early phases of the project construction to be used for traffic advisories during the remaining construction phases. Refer the Traffic Control section of the project plans for more detailed information on the precise schedule for installation of the two US321 DMSs.

3.3 BASIS OF PAYMENT

There will be no direct payment for work covered in this section. Payment at the contract unit prices for the various items in the contract will be full compensation for all work covered in this section.

4. ELECTRICAL SERVICE

4.1 DESCRIPTION

Comply with the Standard Specifications and these Project Special Provisions. At locations called out in the Signing Plans, install new electrical service. All work involving electrical service shall be coordinated with the appropriate electrical utility company.

4.2 MATERIAL

Construct electrical service installations in accordance with the Standard Specifications. For locations shown on the Signing Plans requiring new electrical service, provide a service that includes a new external service disconnect (breaker box) and a meter base. Electrical service cable shall run separately to each of the cabinets in 1" (25 mm) rigid metallic conduit (RMC).

Provide an external electrical service disconnect at all new and existing cabinet locations shown on the Signing Plans. Provide a service disconnect with a double pole 50 ampere circuit breaker with a minimum of 10,000 RMS symmetrical amperes short circuit rating in a lockable NEMA 3R enclosure. Provide a ground bus and neutral bus with a minimum of four terminals with a minimum wire capacity of number 14 through number 4.

Coordinate with utility company to ascertain the practicality of installing electrical service at each location before performing any work.

Furnish insulated copper electrical service cable in accordance with the NEC, local codes, and the Standard Specifications. The gauge of electrical service cables shall be determined in accordance with the distance, voltage and amperage of the service load.

4.3 CONSTRUCTION METHODS

A. Electrical Service

At locations where new electrical service is to be installed on wood or metal poles, furnish and install electrical service as called for in the Signing Plans. After installation of the meter base, the utility company will transfer the existing meter or install a new meter if required and make any necessary connections to the power lines. Ground the new electrical service in accordance with the Standard Specifications and Standard Drawings.

B. External Electrical Service Disconnect

Furnish and install new external electrical service disconnect (breaker box). Route the electrical service through the meter base and service disconnect to the controller cabinet to form a complete electrical service assembly. Ensure that existing grounding system for the existing electrical service with new service disconnect added complies with the grounding requirements of these Project Special Provisions, the Standard Specifications, and the Signing Plans.

4.4 METHOD OF MEASUREMENT

There will be no direct payment for the work covered by this section.

Payment for this work will be covered in the applicable sections of these Project Special Provisions at the contract unit price for "Dynamic Message Sign "DMS-__", and will be full compensation for all work listed above.

5. DYNAMIC MESSAGE SIGN (DMS) SYSTEM

5.1 DESCRIPTION

To ensure compatibility with the existing DMS control software deployed in the State, furnish NTCIP compliant DMS(s) that are Daktronics model number VF-1000-27X90-18-A or approved equivalent. Add and configure the new DMSs into the system using State furnished Vanguard software and computer system. Demonstrate that all functions and features of the Vanguard software are fully operational on the new DMSs without requiring any modification of Vanguard source code and design. Partial or marginal performance of the new DMSs under Vanguard will not be acceptable. Furnish, install, test, integrate and make fully operational two (2) new DMSs at location shown on the Signing Plans.

Furnish an operating Dynamic Message Sign system consisting of, but not limited to, the following:

- LED Dynamic Message Sign (DMS),
- DMS structure and mounting hardware,
- DMS controller, Uninterruptible Power Supply (UPS), cabinet and accessories with interconnect and power cabling and conduit,
- Service equipment,
- All other equipment and incidentals required for furnishing, installing, and testing system components.

Use only UL listed and approved electronic and electrical components in the DMS system.

Provide an installation that meets latest NEC and NESC requirements and all applicable local and state codes.

These Project Special Provisions reference the following:

- Latest edition of National Transportation Communications for ITS Protocol (NTCIP) Joint Standards Committee Recommended Standards applicable to DMS system and requirements of these Project Special Provisions,
- AASHTO 2001, 4th edition and 2002 Interim *to Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals.*

5.2 MATERIALS

A. Environmental Requirements

Construct the Dynamic Message Sign and DMS controller-cabinet so the equipment within is protected against moisture, dust, corrosion, and vandalism.

Design the DMS, controller, cabinet, and accessories for a nominal performance within an ambient temperature range of -30° F to 165° F (-34° C to 74° C) with up to 95% relative humidity. Add fans, heaters and thermostats to the DMS enclosure to meet the operating temperature requirements above. Add a thermostatically controlled fan and thermostat to the cabinet as

described in the subsection titled "DMS Interior Environment Control." Design the system so that interior condensation does not occur and result in reduced visibility or legibility of the DMS elements.

Construct the DMS and housing so that it can withstand AASHTO 2002 fifty (50) years wind speed.

Design the DMS, controller, and associated equipment so that continuous vibration due to wind and traffic do not damage and affect system performance or reduce the legibility of the DMS message.

Transient voltages, surges and sags normally experienced on commercial power lines must not affect the operation of the equipment. Check with the local power and telephone companies to determine if any special design is needed. Include any extra cost, if required, in the contract price for Dynamic Message Sign System.

The presence of ambient electromagnetic fields such as those produced by overhead transmission lines, transformers, and motors must not hinder the performance of the system.

If a DMS or communications line fails, it must not affect the operation of any other non-associated DMS on the system.

Furnish DMS field equipment that meets the latest NEMA Standards for Power Interruption and Transients, Power Service for Traffic Control Systems.

B. LED Dynamic Message Sign (DMS)

Construct the DMS to display at least three lines of text that, when installed, are clearly visible and legible to a person with 20/20 corrected vision from a distance of 900 feet (275m) in advance of the DMS at an eye height of 3.5 feet (1 m) along the axis.

When displaying three lines, each line must display at least fifteen (15) equally spaced and equally sized alphanumeric individual characters. Each character must be at least 18 inches (457 mm) in height and composed from a luminous dot matrix.

1. DMS Enclosure

Construct the DMS with a metal walk-in enclosure excluding the face. Provide an aluminum walking platform inside the enclosure that is at least 28 inches (711 mm) wide. The width of the walking platform shall be free of obstructions to a height of 7 feet (2 m). Construct the enclosure of welded aluminum type 6061-T6, 5052-H38, 5052-H34, or of an Engineer approved alternate at least 1/8-inch (3.175mm) thick. Perform all welding of aluminum and aluminum alloys in accordance with the latest edition of AWS D1.2, Structural Welding Code - Aluminum. Continuously weld the seams using Gas Metal Arc Welding (GMAW).

All exterior and interior DMS enclosure surfaces shall be natural, mill-finish aluminum. All grind marks and discoloration shall be removed from the surfaces.

All nuts, bolts, washers, and other mounting and bonding parts and components used on the exterior of the DMS enclosure shall be corrosion resistant and sealed against water intrusion.

Design and construct the enclosure to resist torsional twist and warp, to present a clean and neat appearance, and to protect the equipment within from moisture, dust, and corrosion.

Provide one key lockable, hinged, gasket-sealed inspection door for service and maintenance along each side of the enclosure. Install one appropriately sized fire extinguisher within 12 inches of each maintenance door. Provide a maintenance walkway that extends from the DMS inspection door to 3 feet (0.9 meter) over the edge of shoulder. Leave no gap between the walkway and the inspection door. Install safety handrails on both sides of the walkway. Equip the DMS enclosure with internal fluorescent lighting controlled by timers installed close to each inspection door. No light emitted from the fluorescent tubes or any other light source inside the enclosure not comprising the display shall leak to the outside of the enclosure. Equip the door with a door-hold-open device. Install duplex utility receptacles every 6 feet (1.8m) along the width of the DMS in convenient locations for powered service tools.

The sign face excluding the front panel shall be covered with a flat black, UV treated, colorfast material such as 3M™ Scotchcal™ non-reflective sheeting. Prior to the application of the sheeting, all surfaces shall be prepared for application per the sheeting manufacturer's recommendation. UV-treat the border and make it colorfast. Construct the border with a minimum width of 18 inches (457mm).

Do not place a manufacturer name, logo, or other information on the front face of the DMS or shield visible to the motorist.

Provide three photoelectric sensors installed inside the DMS enclosure monitoring front, back, and bottom of the sign or the north sky.

Install an EIA/TIA-232E port inside the DMS enclosure to enable a maintenance technician to communicate with the DMS controller that is installed in the roadside cabinet.

Provide power supply monitoring circuitry to detect power failure in the DMS and to automatically report this fault to the Control Software. This requirement is in addition to reporting power failure at the controller cabinet.

Do not paint the stainless steel bolts on the Z-bar assembly used for mounting the enclosure.

2. DMS Interior Environment Control

Design the local field controller to monitor and control the interior DMS environment. Design environmental control to maintain the internal DMS temperature within +/- 10° F (5.6° C) of the outdoor ambient temperature. Provide the DMS environmental control system with four primary subsystems as follows:

- Internal Temperature Sensors – Provide the DMS with two internally mounted temperature sensors which are equipped with external thermocouples and which the Field Controller continuously monitors. Design the Field Controller to use this temperature information to determine when to activate and deactivate the environmental control systems described herein. Locate sensors on opposite ends of the upper 1/3 of the LED display matrix with their external thermocouples attached to and making contact with an LED pixel circuit board. Design the thermocouple and LED board to be easily detachable, in the event that one of the units requires removal and replacement. Provide sensors capable of measuring temperatures from -40° F to +185° F (-40° C to +85° C). Design the Field Controller to automatically shut down the LED display whenever one or both sensors indicates that LED board temperature has exceeded +140° F, and to automatically restart the LED display whenever the suspect temperature falls below +130° F. Design both shutdown and re-start temperature thresholds to be user-

programmable. Design the field controller to report sensor temperatures and DMS shutdown/re-start events to the DMS Control Software.

- Housing Cooling System – Provide the DMS housing with a cooling system which circulates outside air into the DMS housing whenever LED board temperature exceeds a user-programmable threshold. Provide this system with enough ventilation fans to exchange the internal DMS housing air volume at a minimum rate of 4 times per minute. Provide ball-bearing type fans. Mount fans in a line across the upper rear wall of the DMS housing to direct air out of the cabinet. Provide one filtered air intake port for each exhaust fan. Locate intake ports in a line across the lower rear wall of the DMS housing. Provide intake ports with a removable filter that will remove airborne particles measuring 500 microns in diameter and larger. Provide a filter that is of a size and style that is commercially readily available. Initially program the Field Controller to activate the DMS housing cooling system whenever the LED board temperature exceeds +90° F (+32° C) and to turn the cooling system off whenever LED board temperature falls below +85° F (+29° C). On the DMS housing rear exterior wall, cover all air intake and exhaust ports on their top, front, and sides by an aluminum shroud fabricated from 0.090-inch aluminum sheeting. Taper the shrouds at the top to discourage birds from nesting in them. Securely fasten shrouds to the DMS housing, and provide gaskets at the interface to prevent water from entering the DMS. Design all air filters and fans to be removable from inside the DMS housing. Provide the DMS housing cooling system with an adjustable timer that will turn fans off after the set time has expired. Provide a timer that is adjustable to at least four (4) hours, and locate it just inside the DMS housing door, within easy reach of a maintenance technician standing outside the DMS doorway.
- LED Display Cooling System – Provide the DMS with an LED display cooling system which directs air across the LED display modules whenever LED board temperature exceeds a user-programmable threshold. Direct fan-forced air vertically across the backside of the entire LED display matrix using multiple ball-bearing fans. Initially program the Field Controller to activate the LED cooling fan system whenever LED board temperature exceeds +90° F (+32° C) and to deactivate the system whenever LED board temperature falls to +85° F (+29° C). Locate cooling fans so as not to hinder removal of LED display modules and driver boards.
- Front Face Panel Defog/Defrost System – Provide the DMS with a defog/defrost system which circulates warm, fan-forced air across the inside of the polycarbonate front face whenever LED board temperature falls below a user-programmable threshold. Provide multiple ball-bearing fans that provide uniform airflow across the face panel. Initially program the Field Controller to activate the defog/defrost system whenever LED board temperature falls below +40° F (+4° C) and to deactivate the defog/defrost system whenever LED board temperature exceeds +106° F (+41° C). Mount a 100-watt pencil-style heating element in front of each defog/defrost fan to warm the air directed across the DMS face. Design heating elements to be on only when the defog/defrost fans are on.

Install additional fans and/or heaters as needed to maintain the temperature inside the DMS enclosure within the operating temperature range of the equipment within the DMS enclosure as recommended by the equipment manufacturer(s).

3. Front Panel

Protect the DMS face with contiguous, weather-tight, removable panels. Manufacture these panels of sheets of polycarbonate, methacrylate, GE Lexan Type SG300 or equivalent that are ultraviolet protected, have an antireflection coating, and are a minimum of ¼ inch (6 mm) thick. For substitutes, submit one 12" x 12" (300 mm x 300 mm) sample of the proposed material together with a description of the material attributes to the Engineer for review and approval.

Design the panels so they will not warp nor reduce the legibility of the characters. Differential expansion of the DMS case and the front panel must not cause damage to either component or allow openings for moisture or dust. Glare from sunlight, roadway lighting, commercial lighting, or vehicle headlights must not reduce the legibility or visibility of the DMS. Cover the areas of the panels between characters and lines with a flat black, UV-treated, colorfast material to reduce glare.

Install the panels so that a maintenance person can easily remove or open them for cleaning.

4. Display Modules

Manufacture each display module with a standard number of pixels, not to exceed an array of 9 x 5 and be easily removable. Assemble the modules onto the DMS assembly contiguously to form a continuous matrix to display the required number of lines, characters, and character height.

Design display modules that are interchangeable and replaceable without using special tools. All power and communication cables connected to a display module shall be plug-in types to allow easy removal for maintenance and repair.

Construct each display module as a rectangular array of 5 horizontal pixels by 7 to 9 vertical pixels. Provide the module with an equal vertical and horizontal pitch between pixels, and columns that are perpendicular to the rows (i.e., no slant). Design each module to display:

- All upper case letters.
- All punctuation marks.
- All numerals 0 to 9.
- Special user-created characters.

Display upper-case letters and numerals over the complete height of the module. Optimize the LED grouping and mounting angle within a pixel for maximum readability.

5. Discrete LEDs

Provide LEDs that are untinted, non-diffused, high output solid state lamps utilizing indium gallium aluminum phosphide (InGaAlP) technology manufactured by Toshiba or Hewlett-Packard. No substitutions will be allowed. Provide T1 ¾, 5mm size LEDs that emit a true amber color at a wavelength of 590 ± 5 nm.

Provide LEDs with a MTBF (Mean Time Before Failure) of at least 100,000 hours of permanent use at an operating point of 140° F (60° C) or below at a specific forward current of 20mA. Discrete LED failure is defined as the point at which the LED's luminous intensity has degraded to 50% or less of its original level.

Obtain the LEDs used in the display from a single LED manufacturer that have a single part number. Obtain them from batches sorted for luminous output, where the highest luminosity LED is not more than fifty percent more luminous than the lowest luminosity LED when the LEDs are driven at the same forward current. Dot not use more than two successive and overlapping batches in the LED display. Document the procedure to be used to comply with this requirement as part of the catalog cut submittal.

Provide discrete LEDs with a half-power viewing angle of 15 degrees. Half-powering viewing angle is defined as follows: an LED which has a center-axis luminous intensity of calculated candelas at a distance of one foot from the LED while driven at 20 mA forward current is considered to have a 15 degree half-power viewing angle if its luminous intensity is at least half the calculated candelas at a distance of one foot from the LED and at an angle of 7.5 degrees off the LED's center axis while driven with a 20 mA forward current.

Individually mount the LEDs on circuit boards that are at least 1/16" thick in a manner that promotes cooling. Protect all exposed metal on both sides of the LED pixel board, except the power connector, from water and humidity exposure by a thorough application of acrylic conformal coating. Design the boards so bench level repairs to individual pixels, including discrete LED replacement and conformal coating repair is possible.

Operate the LED display at a low internal DC voltage not to exceed 24 Volts.

Design the LED display operating range to be –20° F to +140° F (-29° C to 60° C) at 95% relative humidity, non-condensing.

Supply the LED manufacturer's technical specification sheet with the catalog cuts.

If a superior LED or construction method becomes available between the period that the sign assembly is procured and prior to the actual construction of a given sign assembly, the Engineer has the option to direct the manufacturer to utilize the new technology. At such time, the number of populated pixels may be re-evaluated. Any cost increase or decrease associated with such an order will be restricted to documented changes in material and labor cost.

6. LED Power Supplies

Power the LED Display by means of multiple regulated switching DC power supplies that operate from 120 volts AC input power and have an output of 24 volts DC or less. Wire the supplies in a redundant parallel configuration that uses multiple power supplies per display. Provide the supplies with current sharing capability that allows them to provide equal amounts of current to their portion of the LED display. Provide power supplies rated such that if one supply fails the remaining supplies will be able to operate their portion of the display under full load conditions (all pixels on at maximum brightness) and at a temperature of 140° F (60° C).

Provide power supplies to operate within a minimum input voltage range of +90 to +135 volts AC and within a temperature range of –22° F to 140° F (-30° C to +60° C). Power supply output at 140° F must not deteriorate to less than 65% of its specified output at 70° F (21° C). Provide power supplies that are overload protected by means of circuit breakers, and that have an efficiency rating of at least 75%, a power factor rating of at least .95, and are UL listed. Provide all power supplies from the same manufacturer and with the same model number. Design the power driver circuitry to minimize power consumption.

Design the Field Controller to monitor the operational status (normal or failed) of each individual power supply and be able to display this information on the Client Computer screen.

7. LED Pixels

A pixel is defined as the smallest programmable portion of a display module that consists of a cluster of closely spaced discrete LEDs. Design each pixel to be a minimum of 2" (50 mm) in diameter.

Pixels shall be constructed with two strings of LED's. The number of LEDs in each string shall be determined by the manufacturer to produce the candela requirement as stated herein.

Each pixel shall produce a luminous intensity of 40 Cd when driven with an LED drive current of 20 mA per string.

LED pixels shall be driven with direct-drive pulse width modulation. Maximum pulse amplitude shall not exceed 30 mA.

Power the LEDs in each pixel in strings. Use a redundant design so that the failure of an LED in one string does not affect the operation of any other string within the pixel. Provide the sign controller with the ability to detect the failure of any LED string and identify which LED string has failed. Submit a complete schematic of the LED power and driver circuits with the catalog cuts.

Protect LEDs from degradation due to sunlight via flat black louvers or a functionally equivalent methodology. Place these louvers or equivalent behind the front panel. Use a method that does not reduce the display viewing-angle below that provided by the LED. Install the louvers or equivalent in such a way as to promote cooling of the LEDs and so that they are easily removable for cleaning or maintenance.

8. Character Display

Design display modules to be easily removable without the use of tools. Position cooling fans so they do not prevent removal of an LED pixel board or driver board.

Use continuous current to drive the LEDs at the maximum brightness level. Use Pulse Width Modulation (PWM) to dim the sign to achieve the proper brightness for a given condition. Design the light levels to be adjustable for each DMS / controller so the Engineer may set levels to match the luminance requirements at each installation site.

Design the controller to automatically detect failed LED strings or drivers and initiate a report of the event to the Control Software. Design the controller to be able to read the internal temperature of the DMS enclosure and the ambient temperature outside the DMS enclosure and report these to the Control Software.

9. Display Capabilities

Design the DMS with at least the following message displays:

- Static display
- Flashing display with Dynamic flash rates
- At least two alternating Static and / or Flashing sequences (multi-page messages)

C. DMS Enclosure Structure Mounting

Mount the DMS enclosure and interconnect system securely to supporting structures of the type specified in the Plans. Design the DMS enclosure supports and structure to allow access to the DMS enclosure inspection door.

Submit plans for the DMS enclosure, structure, mounting description and calculations to the Engineer for approval. Have such calculations and drawings approved by a Professional Engineer registered in the state of North Carolina, and bear his signature, seal, and date of acceptance.

Provide removable lifting eyes or the equivalent on the DMS enclosure rated for its total weight to facilitate handling and mounting the DMS enclosure.

Design the DMS structure to conform to the applicable requirements of the *Standard Specifications for Structural Supports for Highway Signs, Luminaires*, and the section titled "Dynamic Message Sign Assembly" of these Project Special Provisions.

D. DMS / DMS Controller Interconnect

Furnish and install all necessary cabling, conduit, and terminal blocks to connect the DMS and the DMS controller. Use approved manufacturer's specifications and project plans for cable and conduit types and sizes.

Ensure the controller is able to communicate with the DMS when installed at the separation distance shown on the Signing Plans.

E. DMS Controller and Cabinet

Furnish and install one DMS controller with accessories per DMS in a protective cabinet at locations approved by the Engineer.

Mount the controller cabinet on a concrete base at ground level close to and in advance of the DMS support structure. Locate the cabinet so that a person working at the cabinet can see the face of the DMS.

Provide the DMS controller as a software-oriented microprocessor and with resident software stored in non-volatile memory. The Control Software, controller and communications must comply with the NTCIP Standards identified in these project special provisions. Provide sufficient non-volatile memory to allow storage of at least 500 multi-page messages and a test pattern program.

Furnish the controller cabinet with, but not limited to, the following:

- Power supply and distribution with back panel
- Power line filtering hybrid surge protectors
- Radio Interference Suppressor
- Communications surge protection devices
- Industrial-Grade UPS system and local disconnect
- Microprocessor-based controller
- Lamp driver and control system (unless integral to the DMS)
- Industrial-grade dial-up modem and interface cable

- Industrial-grade telephone line surge and lightning protector
- Serial interface port for local laptop computer
- Local control panel with Remote / Local control switch
- Interior lighting and duplex receptacle
- Adjustable shelves as required for components
- Temperature control system
- All interconnect harnesses, connectors, and terminal blocks
- All necessary installation and mounting hardware

Furnish the DMS controller and associated equipment completely housed in a NEMA 3R cabinet made from 5052-H32 sheet aluminum at least 1/8" (3.175 mm) thick. Use natural aluminum cabinets and apply an anodized finish after welding. Perform all welding of aluminum and aluminum alloys in accordance with the latest edition of AWS D1.2, Structural Welding Code - Aluminum. Continuously weld the seams using Gas Metal Arc Welding (GMAW).

Slant the cabinet roof away from the front of the cabinet to prevent water from collecting on it.

Do not place a manufacturer name, logo, or other information on the faces of the controller cabinet visible to the motorist.

Provide cabinets capable of housing the components and sized to fit space restrictions. Design the cabinet layout for ease of maintenance and operation, with all components easily accessible. Submit a cabinet layout plan for approval by the Engineer.

Locate louvered vents with filters in the cabinet to direct airflow over the controller and auxiliary equipment, and in a manner that prevents rain from entering the cabinet. Fit the inside of the cabinet, directly behind the vents, with a replaceable, standard-size, commercially available air filter of sufficient size to cover the entire vented area.

Provide a torsionally rigid door with a continuous stainless steel hinge on the side that permits complete access to the cabinet interior. Provide a gasket as a permanent and weather resistant seal at the cabinet door and at the edges of the fan / exhaust openings. Use a non-absorbent gasket material that will maintain its resiliency after long-term exposure to the outdoor environment. Construct the doors so that they fit firmly and evenly against the gasket material when closed. Provide the cabinet door with louvered vents near the bottom, and with air filters as described in the paragraph above.

Provide a Plexiglas rack of appropriate size at a convenient location on the inside of the door to store the cabinet wiring diagrams and other related cabinet drawings. Provide a Corbin #2 main door lock made of non-ferrous or stainless steel MATERIAL. Key all locks on the project alike, and provide ten (10) keys to the Engineer. In addition, design the handle to permit padlocking.

Provide the interior of the cabinet with ample space for housing the controller and all associated equipment and wiring; use no more than 50% of the useable space in the cabinet. Leave a minimum of 20% of all shelf space free for future expansion after all required equipment is installed. Provide ample space in the bottom of the cabinet for the entrance and exit of all power, communications, and grounding conductors and conduit. Provide an additional 2" (50mm) conduit entrance for future use.

Arrange the equipment so as to permit easy installation of the cabling through the conduit so that they will not interfere with the operation, inspection, or maintenance of the unit. Provide adjustable

metal shelves, brackets, or other support for the controller unit and auxiliary equipment. Leave a 3" (75 mm) minimum clearance from the bottom of the cabinet to all equipment, terminals, and bus bars.

Provide power supply monitoring circuitry to detect power failure and to automatically report the occurrence to the Control Software.

Install two 15-watt fluorescent light strips with shields, one in the top of the cabinet and the other under the bottom shelf. Design both lights to automatically turn on when the cabinet door is opened and turn off when the door closes.

Mount and wire a 120V (±10%) GFI duplex receptacle of the 3-wire grounding type in the cabinet in a location that presents no electrical hazard when used by service personnel for the operation of power tools and work lights.

No cabinet resident equipment shall utilize the GFI receptacle. There shall be one spare non-GFI receptacle for future addition of equipment.

Mount a bug-proof and weatherproof thermostatically controlled fan and safety shield in the top of the cabinet. Size the fan to provide at least for two air exchanges per minute. Fuse the fan at 125% of the capacity of the motor. The magnetic field of the fan motor must not affect the performance of the control equipment. Use a fan thermostat that is manually adjustable to turn on between 80°F and 160°F (26°C and 72°C) with a differential of not more than 10°F (4°C) between automatic turn-on and turn-off. Mount it in an easily accessible location, but not within 6" (150 mm) of the fan.

Install additional fans and/or heaters as needed to maintain the temperature inside the cabinet within the operating temperature range of the equipment within the cabinet as recommended by equipment manufacturer(s).

1. Wiring

The requirements stated herein shall apply whenever and wherever electrical wiring is needed for any DMS system assemblies and subassemblies such as controller cabinet, DMS enclosure, electrical panel boards and etc.

Neatly arrange and secure the wiring inside the cabinet. Where cable wires are clamped to the walls of the control cabinet, provide clamps made of nylon, metal, plastic with rubber or neoprene protectors, or similar. Lace and jacket all harnesses, or tie them with nylon tie wraps spaced at 6" (150 mm) maximum to prevent separation of the individual conductors.

All conductors shall be individually and uniquely labeled. All conductor labels shall be clearly visible without moving the conductor. All terminal conductors shall connect to the terminal strip in right angles. Excess conductor shall be removed before termination of the conductor. The conductor shall be molded in such a fashion as to retain its relative position to the terminal strip if removed from the strip. No conductor shall run across a work surface with the exception of connecting to that work surface. No conductor bundles can be support by fasteners that support work surfaces. All connectors, devices and conductors shall be installed in accordance to manufactures guidelines. All wiring shall comply with the latest NEC guideline in effect during installation. No conductor or conductor bundle may hang loose or create a snag hazard. All conductors shall be protected from damage. All solder joints shall be completed using industry accepted practices and shall not fail due to vibration or movement. All welds must

be in a manner that will not fail due to vibration. Lamps and control boards shall be protected from damage.

Insulate all conductors and live terminals so they are not hazardous to maintenance personnel.

Route and bundle all wiring containing line voltage AC and / or shield it from all low voltage control circuits. Install safety covers to prevent accidental contact with all live AC terminals located inside the cabinet.

Use industry standard, keyed-type connectors with a retaining feature for connections to the Controller.

Label all equipment and equipment controls clearly.

Supply each cabinet with three complete sets of wiring diagrams that identify the color-coding or wire tagging used in all connections. Furnish a water-resistant packet adequate for storing wiring diagrams, operating instructions, and maintenance manuals with each cabinet.

2. Back Panels and Terminal Blocks

Include a fully wired equipment back panel(s) mounted on the lower rear inside of the wall of each cabinet below the equipment backs and shelves. Provide a detailed layout for approval by the Engineer.

Locate terminal blocks on the back panel so they are accessible to the extent that it is not necessary to remove the electronic equipment from the cabinet to make an inspection or connection, and so they do not upset the entrance, routing, and connection of incoming field conductors. Use two-position multiple pole barrier-type terminal blocks. Identify all terminals by permanent legends attached to the blocks. Do not allow electrically live parts to extend beyond the barriers.

3. Power Supply and Circuit Protection

Design the DMS and controller for use on a system with a line voltage of 120V $\pm$ 10% at a frequency of 60 Hz $\pm$ 3 Hz. Under normal operation, do not allow the voltage drop between no load and full load of the DMS and its controller to exceed 3% of the nominal voltage.

Blackout, brownout, hunting, line noise, chronic over-voltage, sag, spike, surge, and transient effects are considered typical AC voltage defects. Protect the DMS system equipment so that these damaging defects do not interrupt its operation. Equip all cabinets with devices to protect the equipment in the cabinet from damage due to lightning and external circuit power and current surges.

4. Circuit Breakers

Protect the DMS controller, accessories, and cabinet utilities with thermal magnetic circuit breakers. Provide the controller cabinet with a main circuit breaker sized according to the NEC. Use appropriately sized branch circuit breakers to protect the controller and accessories and for servicing DMS equipment and cabinet utilities.

5. Surge Suppressor

Install and clearly label filtering hybrid power line surge protectors on the load side of the branch circuit breakers in a manner that permits easy servicing. Ground and electrically bond the surge protector to the cabinet within 2" (50 mm).

Design the power line surge protector to meet the following requirements:

Peak surge current occurrences	20 minimum
Peak surge current for an 8 x 20 microsecond waveshape	20,000 amperes
Clamp voltage	280 volts @ 20KA
Response time	Voltage never exceeds 250 volts during surge
Maximum current for filtered output	20 amperes for 120VAC*
Temperature range	-10°F to +150°F (-40°C to +85°C)

* Capable of handling the continuous current to the equipment

6. Radio Interference Suppressor

Provide each controller cabinet with sufficient electrical and electronic noise suppression to enable all equipment in it to function properly. Provide one or more radio interference suppressors (RIS) connected between the stages of the power line surge suppressor that minimize interference generated in the cabinet in both the broadcast and the aircraft frequencies. Each RIS must provide a minimum attenuation of 50 decibels over a frequency range of 200 KHz to 75 MHz. Clearly label the suppressor(s) and size them at least at the rated current of the main circuit breaker but not less than 50 amperes.

Provide RIS that are hermetically sealed in a substantial metal case which is filled with a suitable insulating compound and have nickel-plated 10/24 brass stud terminals of sufficient external length to provide space to connect #8 AWG wires. Mount them so that the studs cannot be turned in the case. Properly insulate ungrounded terminals from each other, and maintain a surface linkage distance of not less than ¼" (6.3 mm) between any exposed current conductor and any other metallic parts. The terminals must have an insulation factor of 100-200 MΩ, dependent on external circuit conditions. Use RIS designed for 120 VAC ± 10%, 60Hz, and which meet the standards of UL and the Radio Manufacturers Association.

7. Communications Surge Protector

Equip the cabinet with properly labeled hybrid data line surge protectors that meet the following general requirements:

Surge current occurrences at 2000 ampere, 8 x 20 microsecond waveform	> 80
Surge current occurrences at 400 ampere, 10x700	> 80

microsecond waveform	
Peak surge current for 8 x 20 microsecond waveform	10,000 A (2500 A/line)
Peak surge current for 10x700 microsecond waveform	500 A/line
Response time	< 1 nanosecond
Series resistance	< 15 Ω
Average capacitance	1500 pF
Temperature range	-10°F to 150°F
Clamp Voltage	As required to match equipment in application

8. Lightning Arrester

Protect the system with an UL-approved lightning arrester installed at the main service disconnect. It shall meet the following requirements:

Type of design	Silicon Oxide Varistor
Voltage	120/240 Single phase, 3 wires
Maximum current	100,000 amps
Maximum energy	3000 joules per pole
Maximum number of surges	Unlimited
Response time one milliamp test	5 nanoseconds
Response time to clamp 10,000 amps	10 nanoseconds
Response time to clamp 50,000 amps	25 nanoseconds
Leak current at double the rated voltage	None
Ground Wire	Separate

Protective devices may share a common neutral bus line from their point of attachment to the back panel neutral bus.

9. Uninterruptible Power Supply (UPS)

Provide the cabinet with an industrial grade UPS unit with AC line voltage conditioning capability, operating on a 120 volts AC, 60 Hz commercial line voltage. The unit must supply continuous power to operate the equipment connected to it if the primary power fails. The UPS must detect a power failure and provide backup power within twenty (20) milliseconds. Transition to the UPS source from primary power must not cause loss of data or damage to the equipment being supplied with backup power. Provide an UPS with at least three outlets for supplying conditioned AC voltage to the DMS controller and an industrial-grade dial-up modem. Equipment connected to the UPS must operate without interruption during line voltage variations

of 88 volts AC to 140 volts AC. Mount backup batteries external to the UPS on ½" (12.5 mm) thick plywood to separate them from concrete floor and aluminum cabinet structure. Provide an UPS capable of operating within an ambient temperature range from -40° F to +185° F (-40° C to +85° C) and at up to 95% humidity, non-condensing.

Provide a **Clary SP 1000U** or an approved equivalent UPS unit capable of supplying thirty (30) minutes of continuous backup power to the equipment connected to it when these equipment are operating at full load.

10. Communications Interface

The controller will have the following interface ports:

- An EIA/TIA-232E serial interface port to drive an asynchronous industrial-grade modem for communications with the Server, Client, or Laptop Computer over dial-up lines or on point-to-point and multi-point networks.
- An EIA/TIA-232E serial interface port to allow onsite access by an operator with a Laptop Computer. Permanently install a cable for communications between the two in an easily accessible location inside the DMS controller cabinet.

Include circuitry to automatically reset the modem after power interruption or fluctuation.

Equip the controller cabinet with all modems and other equipment necessary to allow the controller to be addressed across a dial-up or cellular phone link. Provide communications data transmission at an user-selectable asynchronous rate between 1200 and 33.6 kbps.

11. Telephone Modem

Modem shall be an external industrial-grade unit. The modem design must have integral transient protection and Galvanic Isolation between line, RS232/422/485 ports, and power connections. The modem must have a watchdog circuitry to continuously monitor the power supply, internal hardware, and operational software. In the event of a hardware or software problem the modem shall automatically reset itself. The unit must meet the following minimum specifications:

Telephone Modem	
Max Data Rate	33.6 kbps (V.34)
Compatibility	V.34, V.32bis, V.32, V.22, V.22A/B, V.23, V.21, Bell212a &103
Settings	AT-Commands & Switches
Transmission	Asynchronous and Synchronous
Data Compression	V.42bis and MNP5
Error Correction	V.42, MNP2-4, and MNP10
REN	0.3 - 1.0
Line Jack	RJ11/12
Phone Jack	RJ11/12
RS 232 Port	

Max RS232 Rate	115.2 kbps
RS232 Signal Support	TXD, RXD, CTS, RTS, DCD, DTR, DSR, RI, GND
RS232 Connector	DB9 Female
Command Set	All Standard AT and S Register commands including Class 1 and Class 2 fax commands
RS422/485 Port	
RS422 Mode	4 wires full duplex
RS485 Mode	2 or 4 wires party-line operation (halfduplex)
Signal Rate	Standard Rates up to 115.2 kbps
RS422/485 distance	Up to 0.5 miles
Status LEDs	
Carrier Detect (CD)	The modem has detected a carrier on the phone line
Data Terminal Ready (TR)	The PC has established a connection to the modem and is ready
Received Data (RD)	Flashes as data is received from the phone line
Transmit Data (TD)	Flashes as data is sent out the phone line
Power	On when power is present
General Specifications	
Input power	10-60 VDC or 115 VAC
Operating Temperature	-22 °F to 158 °F (-30° C to 70° C)
Storage Temperature	-40° F to 185 °F (-40° C to 85° C)
Humidity	Up to 95%RH
Flammability	UL94V-0 MATERIAL
EMI Emissions	FCC part 15, ICES-003, EN5502
EMC Immunity	EN50082-1, IEC801-2,3,4
Electrical Safety	UL 508, CSA C22.2/14, IEC1010
Surge Withstand	IEEE-472 (ANSI C37.90)
Hazardous Locations	UL 1604, CSA C22.2/213-M1987, EN50021 (Zone 2)
PLC Discrete I/O Interface (if required by the Project Special Provisions or to implement a functional requirement)	
Trigger Input from PLC	Connects to PLC output. Starts auto dialing upon transition from OFF to ON. Modem will stay connected while input is ON
Voltage Range	9 to 30 VDC

Input Current	6.5 mA @ 24VDC
Max OFF Voltage	5VDC
On-Line Output (to PLC)	Output is ON as long as a connection exists (carrier detect)
Output Characteristics	Sourcing - Switches supply power
Max Output Current	100 mA

12. Modem and Field Controller Reset Device

Install a device in the controller cabinet to remotely rest the modem and the DMS field controller.

13. Telephone Line Surge and Lightning Protector

Provide phone line surge and lightning protectors that are UL rated for industrial use and meet the following specifications:

Technology	Solid state sidactors with fast acting fuses and resistors
Usage	Telephone Line
Ports Protected	1 (2 lines per port)
Connectors	RJ11/12
Surge Capacity	1.9 kA / line
Clamp & Rated Voltage	270 V and 200 V
Max Frequency	50 MHz
Operating Temperature	-40° F to 185 ° F (-40° C to +85° C)
Max Inline Resistance	22 Ohms
Ratings	UL 497A, IEC801-5, CCITT (ITU-T) K17

14. Local Control Panel

Provide a Local Control Panel (LCP) with waterproof switches for at least the following functions:

- On / Off Switch: controls power to the DMS and the DMS controller. You may locate this switch elsewhere in the cabinet with the approval of the Engineer.
- Control Mode Switch: for setting the DMS operation mode to either Remote (Server/Client) Mode or Local Mode.
- Message Selection Switch: Selects either a blank message or any of the messages stored in the DMS controller when in the Local Control Mode. There shall be a LCD display allowing messages to be previewed prior to activation. While a message is being previewed, any failed pixel within the message or outside the

message area shall be flashing so they would be repaired prior to the message activation.

- Message Activation Switch: to activate the message selected.

The LCP displays at least the following:

- Controller On
- Number of message displayed
- Error or fault detected along with indication of error type

15. Controller Address

Assign each DMS controller a unique address that is set by hard wiring to ground the appropriate conductors in the controller cabinet or by an Engineer-approved alternate method. Preface all commands from the Control Software with a particular DMS controller address. The DMS controller compares its address with the address transmitted; if the addresses match, then the controller processes the accompanying data.

16. Controller Modes of Operation

Provide each controller with two possible modes of operation based on the point of control:

- Remote Mode: The Control Software controls DMS display
- Local Mode: An on-site operator controls DMS display using the LCP or a laptop computer

The controller will report its operational mode status to the Control Software when polled.

17. Controller Functions

Design the DMS controller to continuously control and monitor the DMS independent of the Control Software.

Link the DMS controller to the Control Software; it will decode the address of every transmission made to it from the Control Software and reject any transmission that does not begin with its unique address.

Design the controller to display on the sign a message sent by the Control Software, a message stored in the sign controller memory, or a message input on-site by an operator.

The Control Software can direct the controller to perform the following major tasks: create, edit, and / or delete messages and their parameters, stop or change the message being displayed, and perform diagnostic and test programs.

Include the following functions in the controller and software:

- The DMS controller acknowledges all transmissions from the Control Software; sending a negative response if an error is detected, or a confirming response if it receives a valid transmission,
- The DMS controller is able to start up the DMS,
- Message Creation: The DMS Control Software is able to write and erase messages to the DMS remotely, and store the messages in non-volatile memory remotely,

- Display one of three message types: static, flashing, or a multi-page message of at least two pages,
- Display any message stored in non-volatile memory,
- Change existing messages in non-volatile memory,
- Enter new messages into non-volatile memory.

For each message, the operator may define a display time in minutes (65,000 minutes max.). When this display time has expired, the controller will blank the sign and extinguish all LEDs.

For alternating or multi-page messages, the operator may define a display time for each message and a blank-out time (from 0.3 sec to 25 sec in 0.1sec increments) between messages.

For flashing messages, the operator may define a flash rate with a minimum range of 0.5 seconds to 3 seconds, adjustable in half-second increments.

Provide each DMS controller with error detection and reporting features that guard against incomplete or inaccurate transmission, including:

- Validating the contents of all received transmissions for logic or data errors.
- Monitoring the status of communication lines to detect a malfunction or break.

a. Error and Failure Reports:

- Power failure
- Data transmission error
- Receipt of invalid data
- Communications failure recovery
- DMS controller failure
- Power recovery
- LED and module status

b. Error and Failure Responses:

- Power Failure: The controller initiates a report of the event to the Control Software. The controller automatically resumes normal operation after the AC power restoration and reports this to the Control Software
- LED, LED Driver, or Power Supply Failure: The controller detects the failure and automatically reports it to the Control Software
- Communications Failure with the Control Software while in the remote Mode: the controller displays a pre-programmed message unless the link has been restored before a user-selectable period (between 0 and 24 hours) has elapsed

Provide the DMS controller with a watchdog timer to detect controller failures and to reset the microprocessor, and with a battery backed-up clock to maintain an accurate time and date reference. Set the clock through an external command from the Control Software or the LCP.

18. DMS Controller Commands

Include these commands at a minimum in the controller:

1. Displays the last command from Control Software.
2. Status request: Provides status report including:
    - DMS ID or address
    - DMS operational mode: Remote or Local
    - Pixel status: Shows operational status of all pixels on the DMS
    - Power supply status
3. Message display command: Shows text and display parameters of the message currently displayed on the DMS.
4. Light level switching command: Selects Dim, Normal, or Bright Light level control in two modes: automatic (photoelectric sensor control), Control Software override.
5. Program command: Programs the display of a message in memory at a selected date and time.
6. Abort and / or Sign off command.

19. DMS Controller Memory

Design each DMS controller with its own local non-volatile memory. Use the non-volatile memory to store and reprogram at least one test pattern sequence and 500 messages containing a minimum of two pages of 45 characters per page. The Engineer will furnish the initial set of messages. Load these messages into both the Control Software library and the DMS controller's non-volatile memory. The Control Software can upload messages into and download messages from each controller's non-volatile memory remotely.

Messages uploaded and stored in the controller's non-volatile memory may be erased and edited using the Control Software and the controller. New messages may be uploaded to and stored in the controller's non-volatile memory using the Control Software and the controller. These actions shall be accomplished without removing the non-volatile memory from the controller and installing another non-volatile memory in the controller.

F. Photo-Electric Sensors

Install three photoelectric sensors with ½" (12.5mm) minimum diameter photosensitive lens inside the DMS enclosure. Use sensors that will operate normally despite continual exposure to direct sunlight. Place the sensors so they are accessible and field adjustable. Point one sensor north or bottom of the sign. Place the other two perpendicular to and pointed away from the front and rear of the DMS, respectively.

Provide controls so that the Engineer can field adjust the following:

- The light level emitted by the pixels elements in each Light Level Mode.
- The ambient light level at which each Light Level Mode is activated.

G. Circuit Breakers, Panels, and Enclosures

Use circuit breakers and panels that meet the requirements of UL Standard 489 "Molded-Case Circuit Breakers and Circuit-Breaker Enclosures, and UL Standard 67 "Electric Panelboards". Provide corrosion resistant enclosures that meet UL Standard for Safety for Cabinets and Boxes, and UL Standard for Safety for Industrial Control Equipment and sections 1098 and 1700 of the Standard Specifications and applicable addenda and typical drawings.

Use only molded case, thermal magnetic trip type breakers. Use circuit breaker panelboard enclosures, marked as suitable for use as service equipment, and neatly and permanently label them as shown on the plans. Use circuit breaker panelboard enclosures that are lockable with padlocks without modifying the enclosure. Provide enclosures marked as suitable for service equipment.

H. Service Poles

Use service poles for this project that meet requirements of these Project Special Provisions. Install separate conduits on the service pole for telephone and electrical service. The Engineer must approve the locations of service poles.

I. Equipment List

Provide a general description of all equipment and all information necessary to describe the basic use or function of the major system components. Include a general "block diagram" presentation. Include tabular charts listing auxiliary equipment, if any is required. Include the nomenclature, physical and electrical characteristics, and functions of the auxiliary equipment unless such information is contained in an associated manual; in this case include a reference to the location of the information. Include an itemized list of equipment costs.

Include a table itemizing the estimated average and maximum power consumption for each major piece of equipment.

J. Character Set Submittal

Submit an engineering drawing of the DMS character set including 26 upper case letters, 10 numerals, a dash, a plus sign (+), a designated lane diamond, a slash, an ampersand, and arrows at 0, 45, 90, 135, 180, 225, 270, and 315 degrees.

K. Wiring Diagrams and Theory of Operation

Provide a wiring diagram for each DMS and each controller cabinet, as well as interconnection wiring diagrams for the system as a whole.

Provide the theory of operation of the system components in a clear, concise manner supported by detailed and complete schematics to component level, logic and data flow diagrams, one-function diagrams, and voltage levels. Include timing and waveform diagrams of the column and row driving signals, the enable signals, and other pertinent output signals. Provide schematic and pictorial diagrams that are complete and accurate as required to supplement the text material and which make the books a self-contained technical information source. Use a logical development starting with a system block level and proceeding to a circuit analysis. Include details in these analyses whenever circuits are not normally found in standard textbooks. Fully describe the application of new theoretical concepts. Where the design allows for operation in several different modes, include an operational description of each mode. Include a pictorial diagram of all components on circuit boards. Document procedures to program the DMS controller memory, including conversion tables of message characters to the codes stored in memory.

Complete and detailed schematic diagrams to component level shall be provided for all DMS assemblies and subassemblies such as driver boards, control boards, DMS controller, power supplies, and etc. Such schematics shall enable an electronics technician to successfully identify any component on a board or assembly and trace its incoming and outgoing signals.

5.3 CONSTRUCTION METHODS

A. Description

This article establishes practices and procedures and gives minimum standards and requirements for the installation of Dynamic Message Sign systems, auxiliary equipment and the construction of related structures.

Provide electrical equipment described in this specification that conforms to the standards of NEMA, UL, or Electronic Industries Association (EIA), wherever applicable. Provide connections between controllers and electric utilities that conform to NEC standards. Express wire sizes according to the American Wire Gauge (AWG).

Provide stainless steel screws, nuts, and locking washers in all external locations. Do not use self-tapping screws unless specifically approved by the Engineer. Use parts made of corrosion-resistant materials, such as plastic, stainless steel, brass, or aluminum. Use construction materials that resist fungus growth and moisture deterioration. Separate dissimilar metals by an inert dielectric material.

B. Layout

The Engineer will establish the actual location of each Dynamic Message Sign assembly. Provide the proper elevation, offset, level, and orientation of all DMS assemblies. The location of service poles and controller cabinets as well as conduit lengths as shown in the plans are approximate based on available project data. Make actual field measurements to place conduit and equipment at the required location. Mark the proposed location of circuits and all other components for the Engineer's approval prior to installation. Submit a drawing showing all underground conduits and cables dimensioned from fixed objects or station marks.

C. Construction Submittal

When the work is complete, submit "as built" plans, inventory sheets, and any other data required by the Engineer to show the details of actual construction and installation and all changes made during installation.

The "as built" plans will show: the DMS, controller, and service pole locations; DMS enclosure and controller cabinet wiring layouts; and wire and conduit routing. Include detailed drawings that identify the routing of all conductors in the system by cable type, color code, and function. Clearly label all equipment in the DMS system, controller cabinet, and DMS enclosure.

D. Conduit

Install the conduit system in accordance with NEC requirements for an approved watertight raceway.

Make bends in the conduit so as not to damage it or change its internal diameter. Install watertight and continuous conduit with as few couplings as standard lengths permit.

Clean conduit before, during, and after installation. Install conduit in such a manner that temperature changes will not cause elongation or contraction that might damage the system.

Attach the conduit system to and install along the structural components of the DMS structure assembly with beam clamps or stainless steel strapping. Install strapping according to the strapping manufacturer's recommendations. Do not use welding or drilling to fasten conduit to structural components. Space the fasteners at no more than 4 feet (1.2m) for conduit 1.5" (40 mm) and larger, or 6 feet (1.8 m) for conduit 1.25" (30 mm) and smaller. Place fasteners no more than 3 feet (900 mm) from the center of bends, fittings, boxes, switches, and devices.

Locate underground conduit as shown in the Plans in a manner consistent with these Project Special Provisions.

Where conduit is required beneath pavement, bury it at the required depth prior to laying new pavement, or bore and jack it beneath existing pavement. "Water jetting" is not an acceptable installation method. Plug any abandoned opening for bored or jacked conduit as directed by the Engineer.

Extend conduit stubs for controller cabinets at least 6 inches (150 mm) upward and at least 3 feet (900 mm) downward from the top of the foundation.

Provide caps or plugs made of the same material as the conduit on stub-outs for future use.

Clean conduit after installation by "snaking" with a mandrel of a diameter not less than 85% of the nominal diameter of the conduit. Ensure all conduit runs are free of moisture, trash, and debris before pulling cable. Seal the ends of underground conduit with temporary caps and, after installation of circuits, plug the ends as specified in these Project Special Provisions. Coat field-cut threads and other uncoated metal or damaged galvanizing with 2 coats of zinc-rich paint meeting the requirements of Article 1080-9 of the Standard Specifications. Ream the ends of rigid conduit.

Do not exceed the appropriate fill ratio on all cable installed in conduit as specified in the NEC.

E. Wiring Methods

Do not pull permanent wire through a conduit system until the system is complete and has been cleaned.

Color-code all conductors per the NEC (grounded neutral-WHITE, grounding-BARE or GREEN, and phase conductors RED and BLACK). Use approved marking tape, paint, sleeves or continuous colored conductors for No.8 AWG and larger. Do not mark a white conductor in a cable assembly any other color. You may strip a white, red, or black conductor at all accessible points and use it as a bare equipment-grounding conductor.

Bury underground circuits at the depth shown in the plans and surround with at least 3" (75mm) of sand or earth back-fill free of rocks and debris. Compact backfill in 6" (150 mm) layers. Do not splice underground circuits unless specifically noted in the plans.

F. Equipment and Cabinet Mounting

Mount equipment securely at the locations shown in the plans, in conformance with the dimensions shown, and plumb and level. Install fasteners as recommended by the manufacturer and space them evenly. Use all mounting holes and attachment points for attaching DMS enclosures (and controller cabinets, if required) to structures.

Drill holes for expansion anchors of the size recommended by the manufacturer of the anchors and thoroughly clean them of all debris.

Provide one key-operated, pin tumbler, dead bolt padlock, with brass or bronze shackle and case, conforming to Military Specification MIL-P-17802E (Grade I, Class 2, Size 2, Style A) for each electrical panel and switch on the project. Key all padlocks alike, and provide 10 keys to the Engineer.

Provide cabinets with all mounting plates, anchor bolts, and any other necessary mounting hardware in accordance with the Signal Specifications and the project plans.

Provide Class-A concrete in conformance with Article 1000-4 of the Standard Specifications.

Seal all unused conduit installed in cabinets at both ends to prevent water and dirt from entering the conduit and cabinet.

Install a ground bushing attached inside the cabinet on all metal conduits entering the cabinet. Connect these ground bushings to the cabinet ground bus.

G. Cabinet and System Grounding

Ground the controller cabinet, DMS enclosure, DMS structure, and service entrance equipment per Sections 1098 and 1700 of the Standard Specifications, applicable addenda, typical drawings, the Plans and these Project Special Provisions. Provide grounding circuits that are permanent and electrically continuous with a current carrying capacity high enough and an impedance low enough to limit the potential above ground to a safe level.

Run the power company neutral, conduit grounds, and all equipment grounds directly and independently of the ground bus. Use ground clamps, grounding and bonding bushings, lock nuts, and grounding electrodes that comply with UL Standard Electric Grounding and Bonding Equipment. Use ground rods of 5/8" (16mm) minimum diameter, 10 feet (3 m) long, and made of copper-clad steel.

Make connections between ground electrodes and the ground wire using an exothermic welding process, cadweld or equivalent.

Ensure completed cabinet grounds have a resistance to ground of not more than 20 Ohms.

H. Work Site Clean-Up

Clean the site of all debris, excess excavation, waste packing material, wire, etc. Clean and clear the work site at the end of each workday. Do not throw waste material in storm drains or sewers.

I. Power and Telephone Service

When power and telephone service are required at a DMS location, contact the power and telephone companies, make application, and pay all costs, including the installation charge and monthly usage bills, to assure the ability to complete all work. Pay all power and telephone company charges incurred until the date of acceptance of the project by the Department. Upon acceptance of the project and upon request, the Department will reimburse the actual verified cost of power and telephone company charges, including monthly usage bills.

Provide a power service connection that is a single-phase 120/240 volt 3 wire 60 Hz alternating current supply furnished from the local electric utility to a service pole close to the controller cabinet. Provide a main disconnect switch in a lockable NEMA 3R enclosure located on the service

pole. Use a main-disconnect that is 120/240V, double pole, bolt-in circuit breaker sized according to the NEC to protect the above equipment.

Install a service pole in a location approved by the Engineer and deliver power and telephone service to it. Run power and telephone service to the controller cabinet through separate conduits.

5.4 METHOD OF MEASUREMENT

Each Dynamic Message Sign System consists of LED Dynamic Message Sign, communications equipment, strapping hardware, controller, UPS, cabinet and base, conduit and conduit bodies, wire, connectors, circuit protection equipment, photo-electric sensors, service pole, electrical and telephone service installation, and related service equipment, tools, materials, all related testing, cost of labor, cost of transportation, incidentals, and all other equipment necessary to furnish and install a DMS system as detailed in the previous pages.

5.5 BASIS OF PAYMENT

The quantities of each Dynamic Message Sign System and Maintenance Training as measured will be paid for at the contract lump sum price for "Dynamic Message Sign System "DMS ____"

Payment will be made under:

Dynamic Message Sign System "DMS ____" .....Lump Sum

6. DMS TESTING REQUIREMENTS

6.1 General Test Procedure

Test the DMS system in a series of design approved and functional tests. The results of each test must meet the specified requirements. These tests should not damage the equipment. The Engineer will reject equipment that fails to fulfill the requirements of any test. Resubmit rejected equipment after correcting non-conformities and re-testing; completely document all diagnoses and corrective actions. Modify all equipment furnished under this contract, without additional cost to the North Carolina Department of Transportation, to incorporate all design changes necessary to pass the required tests.

Provide 4 copies of all test procedures and requirements to the Engineer for review and approval at least 40 days prior to the testing start date.

Only use approved procedures for the tests. Include the following in the test procedures:

- A step-by-step outline of the test sequence, showing a test of every function of the equipment or system tested
- A description of the expected nominal operation, output, and test results, and the pass / fail criteria
- An estimate of the test duration and a proposed test schedule
- A data form to record all data and quantitative results obtained during the test.
- A description of any special equipment, setup, manpower, or conditions required by the test

Provide all necessary test equipment and technical support. Use test equipment calibrated to National Institute of Standards and Technology (NIST) standards. Provide calibration documentation upon request.

The Contractor shall notify the Engineer forty days in advance of factory tests.

Failure to conform to the requirements of any test and these specifications shall be counted as a complete failure, and the equipment shall be rejected. Rejected equipment/tests may be retested after all deviations have been corrected. After successful completion of all factory tests, the DMS for this contract will be accepted for shipment to the installation site. The Contractor shall provide the documentation to the Engineer of all test and results.

The approval of test procedures and the Engineers acceptance of DMS tests shall not relieve the Contractor of his responsibility to provide a completely acceptable operating DMS system that meets the requirements as stated herein.

Provide 4 copies of the quantitative test results and data forms containing all data taken, highlighting any non-conforming results and remedies taken, to the Engineer for approval before the next project stage is started. An authorized representative of the manufacturer must sign the test results and data forms.

6.2 Design Approval Tests

A. Procedure and Requirements

Perform the following Design Approval Tests at the manufacturer's facility on the DMS modules, controller, controller cabinet, communications, and all other associated equipment before beginning full production on the units supplied for this Contract.

PROTOTYPE – Manufacture a prototype Dynamic Message Sign and controller of the type and size described in these Project Special Provisions. Test the prototype according to the Design Approval and Operational Tests. When all corrections and changes (if any) have been made, the Department may accept the prototype DMS and controller as the physical and functional standard for the system furnished under this contract. You may use the prototype units on this project if, after inspection and rework (if necessary), they meet all physical and functional specifications. In the case of standard product line equipment, if the Contractor can provide test results certified by an independent testing facility as evidence of prior completion of successful design approval tests, then the Engineer may choose to waive these tests. If the Engineer so chooses, reduce the contract price by the amount bid for these tests.

In each Design Approval Test designated below, successfully perform the tests described in the Check Test below, under the conditions described. Apply the extreme conditions to all associated equipment unless stated otherwise in these Project Special Provisions.

Perform the following Check Tests as a minimum:

- Start-up and operate the DMS locally using the Control Software.
- Use automatic (photoelectric sensor controlled), remote control using Control Software, and local control using Control Software to switch between "dim", "normal", and "bright" light levels.
- Operate the DMS with all display elements flashing continuously for 15 minutes at the maximum flash rate.
- Exercise the DMS by displaying static messages, flashing messages, and alternating static and flashing message sequences.
- Automatically poll the DMS using Control Software at various intervals and verify data received by the Control Software from the DMS.
- Download and edit messages.
- Execute status request on the DMS controller.
- Normal operations during uploading and downloading.
- Display a two-phase flashing message sequence of 45 characters.
- Select messages from the sign controller's local control panel.
- Activate the test sequence at chosen intervals.
- Display and verify several stored messages.
- Display a 2-page diagonal test pattern with half the pixels on and half off, alternating pixels on each page. Display this pattern for 1 hour.

B. Environmental Tests

1. Temperature

a. Stabilize the equipment -10° F (–23° C). After stabilization at this temperature, perform the Check Tests without degradation or failure at both the low and high ends of the input power voltages.

b. Stabilize the equipment at 140 ° F (60 ° C) and operate it as per part a. above.

2. Humidity

a. Maintain the equipment at 140° F (60° C) with a relative humidity of 95% for 48 hours. At the conclusion of the 48 hours period, perform the Check Tests without degradation or failure at both the low and high ends of the input power voltages.

3. Primary Power Variation

a. Voltage: Operate the field equipment with the input line voltage set first at 132V and then at 108V (120V +/- 10%). Operate the equipment for at least 15 minutes at each of these voltages while successfully performing the Check Tests.

b. Frequency: Operate the field equipment with the input line frequency set first at 63 Hz and then at 57 Hz (60Hz +/- 3Hz). Operate the equipment for at least 15 minutes at each of these frequencies while successfully performing the Check Tests.

c. High Frequency: Check Test the field equipment when subjected to the high frequency and voltage transient interference specified in the Transients, Power Service section of the NEMA Standards for Traffic Control Systems while successfully performing the Check Tests.

4. Vibration and Shock:

Subject the field equipment to the vibration and shock tests described in the Vibration Test and Shock Test sections of the NEMA Standards for Traffic Control Systems. This test must not cause degradation of mechanical structure, soldered components, or plug-in components. Successfully perform the Check Tests immediately after completing the Vibration Test.

5. Water Spray Test :

Perform the following water spray test on controller cabinet and DMS enclosure. Spray water from a point directly overhead at an angle of 60° from the vertical axis. Repeat this procedure for each of eight equally spaced positions around the cabinet/enclosure for a period of not less than two minutes in each position. Spray the water using a domestic type sprinkling nozzle at a rate of not less than 1 gallon (3.78 liters) per minute per 1 square foot (.09 square meters) of surface area. Then check the cabinet/enclosure for leakage. Reject or repair the cabinet/enclosure if there is any evidence of leakage and repeat the test.

6. LED Pixel Light Output Test:

Perform a test to confirm that the light output intensity conforms to the requirements of "LED Pixels".

6.3 Operational FACTORY Tests

Perform Operational Factory Tests on the assembled DMS system at the manufacturer's facility prior to shipping. Perform Operational Field Test on each system after it is shipped, installed, and operational.

A. Operational Factory Test

1. Physical Examination

Examine each piece of equipment to verify that the materials, design, construction, markings, and workmanship comply with the mechanical, dimensional, and assembly requirements of these Project Special Provisions.

Perform the following tests as a minimum:

- Verify that all surfaces are free of dents, scratches, weld burns, or abrasions. Round sharp edges and corners.
- Verify bend radius of cables is not excessive or could potentially cause damage.
- Verify all modules, lamps, and components are properly secured.
- Verify that there are no exposed live terminals.

2. Continuity Test

Check the wiring to assure it conforms with the requirements of the appropriate paragraphs of this Specification.

3. Functional Tests

Operate each unit of equipment in the system long enough to permit the equipment temperature to stabilize, and to check and record performance characteristics to ensure compliance with the latest edition of NTCIP Standards as required in these Project Special Provisions.

Conduct approved DMS functional tests on the equipment with the Control Software. Exercise all remote and local monitoring and control functions required by these specifications and display the return status codes from the controller for a period of 72 hours.

Include the following functional tests as a minimum:

- NTCIP exerciser/other testing on the assembled DMS system
  - Verification of all memory requirements
  - Start-up and operation of the DMS locally using the Control Software
- Use automatic (photoelectric sensor controlled), remote control using Control Software, and local control using Control Software to switch between "dim", "normal", and "bright" light levels
- Operation of the DMS with all display elements flashing continuously for one hour at the maximum flash rate
- Exercise the DMS by displaying static messages, flashing messages, and alternating static and flashing message sequences

- Automatically poll the DMS using Control Software at various intervals and verify data received by the Control Software from the DMS
- Demonstration of the writing speed to meet specified requirements.
- Downloading and editing messages
- Execute status request on the DMS controller
- Normal operations during uploading and downloading
- Display two-phase flashing message sequence of 45 characters
- Selection of messages from the sign controller's local control panel
- Test sequence activation at chosen intervals
- Display and verification of all stored messages
- Resumption of standard operation upon interruption of electrical power
- Demonstrate no loss of RAM memory during a 24 hour electrical power outage
- Demonstration of the Failure Detection and Response functions
- Demonstrate proper operation of the Failure Log
- Watchdog timer detection of microprocessor failures and the resetting of the microprocessor
- Non-volatile memory reprogramming requirements
- Set controller clock using the Control Software
- Execute system shut-down using first the Control Software emulator device, and local control panel
- Detection of power failure in the DMS enclosure and reporting of such failure to the Control Software
- Detection of UPS overload. Logging and reporting of such event to the Control Software

Approval of Operational Factory Test does not relieve the Contractor of the requirements to conform to the specifications in these Project Special Provisions.

4. NTCIP Requirements

This portion of the specification defines the detailed NTCIP requirements for the Dynamic Message Signs covered by the procurement package.

a. Definitions

The following terms shall apply within the scope of this procurement specification:

DMS - A Dynamic Message Sign, includes the sign display, controller, cabinet, and other associated field equipment. The specific type of dynamic message sign (i.e., blank-out sign, changeable message sign, character matrix sign, full-matrix

sign, etc.) for this procurement is specified elsewhere within this procurement specification.

FSORS - Full, Standardized Object Range Support for, and proper implementation of, all valid values of an object as defined within the object's OBJECT-TYPE macro in the subject NTCIP standard; this is further defined in two distinct sub-requirements. (1) If the ACCESS of the object is read-write, a Management System shall be able to set the object to any valid value as defined by the SYNTAX and DESCRIPTION fields (except that the value of 'other' need not be supported when such a value is defined) and the indicated functionality shall be provided. (2) The value indicated by the object (e.g., in response to a 'get'), regardless of the ACCESS, shall reflect the current condition per the rules specified in the object's DESCRIPTION.

Management System – A computer system used to control an NTCIP component. This includes any laptop software used for field control as well as the control software.

NTCIP Component – A DMS or a Management System.

NTCIP System – A Management System plus the various DMSs controlled by the Management System.

Response Time – The time to prepare and begin transmission of a complete response containing the requested Application Layer information. This is measured as the time from receipt of the closing flag of the request to the transmission of the opening flag of the response when the device has immediate access to transmit.

b. References

This specification references several standards through their NTCIP designated names. The following list provides the full reference to the current version of each of these standards. In many cases, the standard is more widely known by its original NEMA assigned number; in these cases, the NEMA number is also identified. The content of the NEMA standard is identical to that of the NTCIP standard.

Each NTCIP Component covered by these project specifications shall implement the most recent version of the standard including any and all Approved or Recommended Amendments to these standards. It is the ultimate responsibility of the VENDOR to monitor NTCIP activities to discover any more recent documents.

Table 1: NTCIP Standards

Abbreviated Number	Full Number	Title	Known Amendments
NTCIP 1101	**NTCIP 1101:1997** (NEMA TS 3.2-1996)	*Simple Transportation Management Framework*	Amendment #1 dated November 2, 1998
NTCIP 1201	**NTCIP 1201:1997** (NEMA TS 3.4-1996)	*Global Object Definitions*	Amendment #1 dated November 2, 1998
NTCIP 1203	**NTCIP 1203:1997**	*Object Definitions for*	Amendment #1

	(NEMA TS 3.6-1997)	*Dynamic Message Signs*	dated July 3, 2001
NTCIP 2001	**NTCIP 2001:1997** (NEMA TS 3.3-1996)	*Class B Profile*	Amendment #1 dated November 2, 1998
NTCIP 2101	**NTCIP 2101**	*SP-PMPP/232* *Subnet Profile for PMPP over RS-232*	Amendment #1 dated November 2, 1998
NTCIP 2102	**NTCIP 2102**	*SP-PMPP/FSK* *Subnet Profile for PMPP over FSK Modem*	
NTCIP 2103	**NTCIP 2103**	*SP-PPP/232* *Subnetwork Profile for PPP over RS232 (Dial Up)*	
NTCIP 2104	**NTCIP 2104**	*SP-Ethernet* *Subnet Profile for Ethernet*	
NTCIP 2201	**NTCIP 2201**	*TP-Null* *Transport Profile*	
NTCIP 2202	**NTCIP 2202** (NEMA TS 3.Internet v99.01.03)	*TP-Internet* *Internet Transport Profile (TCP/IP and UDP/IP)*	
NTCIP 2301	**NTCIP 2301**	AP-STMF AP for Simple Transportation Management Framework	

c. General Requirements

i. Subnet Level

Each serial port on each NTCIP Component shall support NTCIP 2103 over a dial-up connection with a contractor provided external modem with data rates of 28.8 kbps, 19.2 kbps, 14.4 kbps, 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps. The NTCIP Component shall be able to make outgoing and receive incoming calls as necessary and support the following modem command sets:

- Hayes AT - Command Set
- MNP5
- MNP10

- V.42bis

Each serial port on each NTCIP Component shall support NTCIP 2103 over a null-modem connection with data rates of 19.2 kbps, 14.4 kbps, 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps.

Each serial port on each NTCIP Component shall support NTCIP 2101 with data rates of 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps.

Additionally, NTCIP components shall support NTCIP 2102 and NTCIP 2104.

NTCIP Components may support additional Subnet Profiles at the manufacturer's option. At any one time, only one Subnet Profile shall be active on a given serial port of the NTCIP Component. The NTCIP Component shall be configurable to allow the field technician to activate the desired Subnet Profile and shall provide a visual indication of the currently selected Subnet Profile.

ii. Transport Level

Each NTCIP Component shall comply with NTCIP 2201 and 2202.

NTCIP Components may support additional Transport Profiles at the manufacturer's option. Response datagrams shall use the same Transport Profile used in the request. Each NTCIP Component shall support the receipt of datagrams conforming to any of the identified Transport Profiles at any time.

iii. Application Level

Each NTCIP Component shall comply with NTCIP 1101 and 2301 and shall meet the requirements for Conformance Level 1 (NOTE - See Amendment to standard).

Each NTCIP Component shall support SNMP traps. An NTCIP Component may support additional Application Profiles at the manufacturer's option. Responses shall use the same Application Profile used by the request. Each NTCIP Component shall support the receipt of Application data packets at any time allowed by the subject standards.

iv. Information Level

Each NTCIP Component shall provide Full, Standardized Object Range Support of all objects required by these procurement specifications unless otherwise indicated below. The maximum Response Time for any object or group of objects shall be 200 milliseconds.

The DMS shall support all mandatory objects of all mandatory Conformance Groups as defined in NTCIP 1201 and NTCIP 1203. Table 2 indicates the modified object requirements for these mandatory objects.

Table 2: Modified Object Ranges for Mandatory Objects

Object	Reference	Project Requirement
ModuleTableEntry	NTCIP 1201 Clause 2.2.3	Shall contain at least one row with moduleType equal to 3 (software). The moduleMake shall specify the name of the manufacturer, the moduleModel shall specify the manufacturer's name of the component and the modelVersion shall indicate the model version number of the component.
MaxGroupAddresses	NTCIP 1201 Clause 2.7.1	Shall be at least 1
CommunityNamesMax	NTCIP 1201 Clause 2.8.2	Shall be at least 3
DmsNumPermanentMsg	NTCIP 1203 Clause 2.6.1.1.1.1	Shall be at least 1*
DmsMaxChangeableMsg	NTCIP 1203 Clause 2.6.1.1.1.3	Shall be at least 21
DmsFreeChangeableMemory	NTCIP 1203 Clause 2.6.1.1.1.4	Shall be at least 20 when no messages are stored.
DmsMessageMultiString	NTCIP 1203 Clause 2.6.1.1.1.8.3	The DMS shall support any valid MULTI string containing any subset of those MULTI tags listed in Table 4
DmsControlMode	NTCIP 1203 Clause 2.7.1.1.1.1	Shall support at least the following modes: Local External central CentralOverride

* The Permanent Messages shall display the content shown in Table 3.

The sign shall blank if a command to display a message contains an invalid Message CRC value for the desired message.

Table 3: Content of Permanent Messages

Perm. Msg. Num.	Description
1	Permanent Message #1 shall blank the display (i.e., consist of and empty MULTI string). It shall have a run-time priority of one (1).

Table 4: Required MULTI Tags

Code	Feature
f1	field 1 - time (12hr)
f2	field 2 - time (24hr)
f8	field 8 – day of month
f9	field 9 – month
f10	field 10 - 2 digit year
f11	field 11 - 4 digit year
fl (and /fl)	flashing text on a line by line basis with flash rates controllable in 0.5 second increments.
fo	Font
jl2	Justification – line – left
jl3	Justification – line – center
jl4	Justification – line – right
jl5	Justification – line – full
jp2	Justification – page – top
jp3	Justification – page – middle
jp4	Justification – page – bottom
Mv	moving text
Nl	new line

Np	new page, up to 2 instances in a message (i.e., up to 3 pages/frames in a message counting first page)
Pt	page times controllable in 0.5 second increments.

The NTCIP Component shall also implement all mandatory and optional objects of the following optional conformance groups with FSORS.

v. Test Heading

(a) Time Management, as defined in NTCIP 1201

(b) Timebase Event Schedule, as defined in NTCIP 1201. The following list indicates the modified object requirements for this conformance group.

Table 5: Modified Object Ranges for the Timebase Event Schedule Conformance Group

Object	Reference	Project Requirement
MaxTimeBaseScheduleEntries	NTCIP 1201 Clause 2.4.3.1	Shall be at least 28
maxDayPlans	NTCIP 1201 Clause 2.4.4.1	Shall be at least 14
maxDayPlanEvents	NTCIP 1201 Clause 2.4.4.2	Shall be at least 10

(c) Report, as defined in NTCIP 1201. The following list indicates the modified object requirements for this conformance group.

Table 6: Modified Object Ranges for the Report Conformance Group

Object	Reference	Project Requirement
maxEventLogConfigs	NTCIP 1201 Clause 2.5.1	Shall be at least 50
eventConfigurationMode	NTCIP 1201 Clause 2.4.3.1	The NTCIP Component shall support the following Event Configuration Modes: onChange greaterThanValue smallerThanValue

MaxEventLogSize	NTCIP 1201 Clause 2.5.3	Shall be at least 200
MaxEventClasses	NTCIP 1201 Clause 2.5.5	Shall be at least 16

(d) PMPP

(e) Font Configuration, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 7: Modified Object Ranges for the Font Configuration Conformance Group

Object	**Reference**	**Project Requirement**
NumFonts	NTCIP 1203 Clause 2.4.1.1.1.1	Shall be at least 4*
MaxFontCharacters	NTCIP 1203 Clause 2.4.1.1.1.3	Shall be at least 127**

*Upon delivery, the first font shall be a standard 18" font. The second font shall be a double-stroke 18" font. The third font shall be a 28" font. The fourth font shall be empty.

**Upon delivery, the first three font sets shall be configured in accordance with the ASCII character set for the following characters:

- "A" thru "Z"- All upper case letters.
- "0" thru "9"- All decimal digits.
- Space (i.e., ASCII code 0x20).
- Punctuation marks shown in brackets [. , ! ? - ‘ ’ “ ” / ( )]
- Special characters shown in brackets [# & * +< >]

(f) DMS Configuration, as defined in NTCIP 1203.

(g) MULTI Configuration, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 8: Modified Object Ranges for the MULTI Configuration Conformance Group

Object	Reference	Project Requirement
DefaultBackgroundColor	NTCIP 1203 Clause 2.5.1.1.1.1	The DMS shall support the following background colors: black
DefaultForegroundColor	NTCIP 1203 Clause 2.5.1.1.1.2	The DMS shall support the following foreground colors: amber
DefaultJustificationLine	NTCIP 1203 Clause 2.5.1.1.1.6	The DMS shall support the following forms of line justification: left center right full
defaultJustificationPage	NTCIP 1203 Clause 2.5.1.1.1.7	The DMS shall support the following forms of page justification: top middle bottom
defaultPageOnTime	NTCIP 1203 Clause 2.5.1.1.1.8	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultPageOffTime	NTCIP 1203 Clause 2.5.1.1.1.9	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultCharacterSet	NTCIP 1203 Clause 2.5.1.1.1.10	The DMS shall support the following character sets: eightBit

(h) Default Message Control, as defined in NTCIP 1203

(i) Pixel Service Control, as defined in NTCIP 1203

(j) MULTI Error Control, as defined in NTCIP 1203

(k) Illumination/Brightness Control, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 9: Modified Object Ranges for the Illumination/Brightness Control Conformance Group

Object	Reference	Project Requirement
dmsIllumControl	NTCIP 1203 Clause 2.8.1.1.1.1	The DMS shall support the following illumination control modes: photocell timer manual
dmsIllumNumBrightLevels	NTCIP 1203 Clause 2.8.1.1.1.4	Shall be at least 16

(l) Auxiliary I/O

(m) Scheduling, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 10: Modified Object Ranges for the Scheduling Conformance Group

Object	Reference	Project Requirement
NumActionTableEntries	NTCIP 1203 Clause 2.9.1.1.1.1	Shall be at least 21

(n) Sign Status, as defined in NTCIP 1203

(o) Status Error, as defined in NTCIP 1203

(p) Pixel Error Status, as defined in NTCIP 1203

(q) Fan Error Status, as defined in NTCIP 1203

(r) Power Status, as defined in NTCIP 1203

(s) Temperature Status, as defined in NTCIP 1203

Install necessary hardware for the support of items q, r, and s above.

Table 11: Some Optional Object Requirements

Object	Reference	Project Requirement
DefaultFlashOn	NTCIP 1203 Clause 2.5.1.1.1.3	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
DefaultFlashOff	NTCIP 1203 Clause 2.5.1.1.1.4	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
DmsMultiOtherErrorDescription	NTCIP 1203 Clause 2.7.1.1.1.20	If the vendor implements any vendor-specific MULTI tags, the DMS shall provide meaningful error messages within this object whenever one of these tags generates an error.

vi. Documentation

Software shall be supplied with full documentation, including a CD-ROM containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

- The relevant version of each official standard MIB Module referenced by the device functionality.
- If the device does not support the full range of any given object within a Standard MIB Module, a manufacturer specific version of the official Standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX and/or DESCRIPTION fields of the associated OBJECT TYPE macro. The filename of this file shall be identical to the standard MIB Module, except that it will have the extension ".man".
- A MIB Module in ASN.1 format containing any and all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.
- A MIB containing any other objects supported by the device.

The manufacturer shall allow the use of any and all of this documentation by any party authorized by the Procuring Agency for systems integration purposes at any time

initially or in the future, regardless of what parties are involved in the systems integration effort.

B. NTCIP Acceptance Testing

The NTCIP requirements outlined above shall be tested thoroughly by one of the following firms:

Trevilon Corp.	Battelle	PB Farradyne
12827 Tewksbury Drive	505 King Avenue	3200 Tower Oaks Boulevard
Oak Hill, VA 20171	Columbus, Ohio 43201	Rockville, MD 20852
Phone: (703) 390 -1053	Phone: (614) 424-6424	Phone: (301) 468 – 5568

The Contractor shall submit to the Engineer for approval a portfolio of the selected firm. This shall include the name, address, and a history of the selected firm in performing NTCIP testing along with references. The Contractor shall also provide a contact person's name and phone number. The Contractor shall submit detailed NTCIP testing plans and procedures including a list of hardware and software to the Engineer for review and approval forty (40) days in advance of a scheduled testing date. These test documents shall be developed by the selected firm based on the NTCIP requirements of these Project Special Provisions. The acceptance test will use the NTCIP Exerciser, and/or other authorized testing tools and will follow the guidelines established in the ENTERPRISE Test Procedures. The test shall be conducted by the firm in North Carolina on the installed system at the presence of the Engineer. The results of the test shall be documented and certified by the firm and submitted by the Contractor to the Engineer for review and approval. In case of failures, the Contractor shall remedy the problem and the Firm retest in North Carolina. This process will continue until all failures are resolved. The Department reserves the right to enhance these tests as deemed appropriate to ensure device compliance.

C. NTCIP Submittal

Project-specific NTCIP manual shall be included in the list of deliverables that thoroughly documents the details associated with the various NTCIP options and features in the system.

D. Operational Field Test

Conduct an Operational Field Test of each DMS system installed on the project to exercise the normal operational functions of the installed operational field equipment. The Operational Field Test will consist of the following tests as a minimum:

1. Physical Examination

Test per section "Physical Examination" above.

2. Continuity Tests

Test per section "Continuity Tests" above.

3. Functional Tests

Perform the following functional tests:

- NTCIP exerciser/other testing on the assembled DMS system.
- Start-up and operation of the DMS locally using a laptop computer.

- Use automatic (photo-electric sensor controlled), DMS Control Software to switch between "dim", "normal", and "bright" light levels.
- Operation of the DMS with all display elements flashing continuously for 10 minutes at the maximum flash rate.
- Exercise the DMS by displaying static messages, flashing messages, and alternating static and flashing message sequences.
- Automatic polling of the DMS by the Control Software at various intervals and verification of data received by Control Software from DMS.
- Downloading and editing messages using Control Software.
- Execute status request on the DMS controller.
- Normal operations during uploading and downloading.
- Display two-phase flashing message sequence of 45 characters.
- Selection of messages from the sign controller's local control panel.
- Test sequence activation at chosen intervals.
- Display and verification of all stored messages.
- Resumption of standard operation upon interruption of electrical power.
- Demonstration of the Failure Detection and Response functions.
- Demonstrate proper operation of the Failure Log.
- Set controller clock using the Control Software.
- Execute system shutdown using first the Control Software and local control panel.
- Detection of power failure in the DMS enclosure and reporting of such failure to the Control Software.

Approval of Operational Field Test results does not relieve the Contractor to conform to the specifications in these Project Special Provisions. If a system does not pass its test, either document a correction or substitute a new unit as approved by the Engineer. Re-test the system until it passes all requirements.

6.4 30-Day Burn-in Period

At the conclusion of successful Field Operational Test, the system can enter the 30-day burn-in period.

During this period, the system will be operated normally and tested on a daily basis. If the system fails because of any Contractor-supplied component(s), the particular component(s) shall be corrected or substituted with other component(s) upon approval from the Engineer, and the tests shall be repeated/restarted. If a component has been modified as a result of the system test failure, a report shall be prepared and delivered to the Engineer prior to retest.

6.5 90 –Day Observation Period

Upon successful completion of thirty (30) days burn-in period, a 90-day Observation Period shall commence. This observation shall consist of a 90-day period of normal operations of the new field equipment without any failure. The 90-day Observation Period shall be warranted by the payment and performance bond. The purpose of this period is to ensure that all components of the system function in accordance with the Plans and these Special Project Provisions over an extended length of time.

All training shall have been completed at least thirty (30) calendar days prior to the start of the 90-Day Observation Period.

Respond to system or component failures (or reported failures) that occur during the 90-day Observation Period within twenty-four (24) hours. Correct said failures within forty-eight (48) hours. Failures that affect any of the major system components for more than forty-eight (48) hours shall suspend the timing of the 90-day Observation Period beginning at the time when the failure occurred. After the cause of such failures has been corrected, timing of the 90-day Observation Period shall resume. System or components failures that necessitate a redesign of any component and failures in any of the major system components exceeding a total of three (3) occurrences, shall terminate the 90-day Observation Period and shall cause the 90-day Observation Period to be restarted from zero when the redesigned components have been installed and/or the failures corrected.

6.6 CONSTRUCTION METHODS

Conduct and provide test for approval by the Engineer. The Engineer or a designated representative reserves the right to witness all tests.

6.7 METHOD OF MEASUREMENT

There will be no direct payment for the work covered by this section.

Payment for this work will be covered in the applicable sections of these Project Special Provisions at the contract unit price for "Dynamic Message Sign System "DMS ____" and will be full compensation for all work listed above.

7. DYNAMIC MESSAGE SIGN ASSEMBLY

7.1 DESCRIPTION

This section includes all design, fabrication, furnishing, and erection of each Dynamic Message Sign (DMS) assembly; maintenance walkway for access to the DMS inspection door; and attachment of the DMS enclosure to the structure in accordance with the requirements of the plans and the provisions of this specification. Fabricate the supporting DMS assembly from tubular steel. The DMS assembly shall be full span (minimum of two vertical supports) with a boxed truss unless shown otherwise on the Signing Plans.

Design the DMS assembly including footings and submit shop drawings for approval.

Where the Standard Specifications or plans require the design of an sign assembly, including footings, submit design computations and shop drawings to the Engineer for acceptance. A Professional Engineer that is registered in the state of North Carolina will prepare such computations and drawings. These must bear his signature, seal, and date of acceptance.

The provisions of Section 900 apply to all work covered by this section.

Design, furnish and install, two (2) new DMS assemblies as shown on the Signing Plans.

7.2 MATERIAL

Use materials that meet the requirements of Division 10 of the Standard Specifications shown below:

Structural steel	Section 1072 and 1096
Class A concrete	Section 1000
Steel bar reinforcement	Section 1070
Anchor bolts	Article 1072-6
Joint sealer	Article 1028-2
Zinc-rich paint	Article 1080-9
High strength bolts, nuts, and washers	Sub-article 1094-1 (A)

7.3 CONSTRUCTION METHODS

A. General

Fabricate the DMS assembly in accordance with the details shown in the approved shop drawings and the requirements of these specifications.

Do not weld, cut, or drill in any manner in the field unless approved by the Engineer.

Drill bolt holes and slots to finished size or you may punch them to finished size, provided the diameter of the punched holes is at least twice the thickness of the metal being punched. Do not flame cut bolt holes and slots.

Use two coats of a zinc-rich paint to touch up minor scars on all galvanized materials.

B. Shop Drawing

Submit to the Engineer for approval a complete design for each DMS assembly, including footings, sign assembly hardware, brackets for supporting the signs and the maintenance walkway. Base the design on the line drawings and wind speed shown in the plans and in accordance with the "Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals".

The manufacturer of the DMS assembly must coordinate with the manufacturer of the DMS to ensure that the sign and the sign structure are totally compatible, operational, and functional as a working unit.

To ensure the correct attachment of the DMS enclosure, submit plans and designs for both the DMS system and the DMS assembly to the Engineer for approval and acceptance. Resolve discrepancies and conflicts arising from non-compatibility of either the assembly or the DMS enclosure through coordination between the structure designers and the sign designers.

Submit thirteen copies of completely detailed shop drawings and one copy of the design computations for the DMS assembly to the Structures Engineer for approval prior to fabrication. Show in the shop drawings complete design and fabrication details including foundations, provisions for attaching DMS and walkway to supporting structures, applicable material specifications, and any other information necessary for procuring and replacing any part of the complete Dynamic message sign assembly.

The Engineer is responsible for evaluation, approval, and final acceptance of all DMS System, software, testing, and training submittals.

Allow a minimum of 50 days for shop drawing approval after the Engineer receives them. If revised drawings are necessary, allow appropriate additional time for review and approval of final shop drawings.

Approval of shop drawings by the Engineer will not relieve the Contractor of his responsibility for the correctness of drawings, or for the fit of all shop and field connections and anchors.

C. Design and Fabrication

1. Dynamic Message Sign Assembly

Fabricate the DMS assembly in accordance with the details shown in the approved shop drawings and with the requirements of these Project Special Provisions.

DMS assembly dimensions shown in the plans were estimated from available project data for bid purposes. The Engineer will determine the actual dimensions from field measurements and DMS enclosure dimensions provided by the enclosure fabricator and will furnish revised plans. You may use a truss design for horizontal components of the supporting structures for the DMS enclosure. Provide permanent camber in addition to dead load camber in accordance with the "Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals". Indicate on the shop drawings the amount of camber provided and the method used in the fabrication of the assembly to obtain the camber.

Attach the DMS assembly to concrete foundations by the use of galvanized anchor bolts. Furnish anchor bolts with galvanized nuts, flat washers and lock washers. Provide anchor bolts that have a right angle bend or anchor plate with a nut at the end you embed in concrete.

Fabricate the attachment assembly for mounting signs in a manner that will ensure easy removal of the signs for repair.

2. Maintenance Walkway

Provide a maintenance walkway, a minimum of 36" (914mm) wide with an open skid-resistant surface and safety railings, on the DMS assembly for access to the DMS inspection door unless specifically stated otherwise in the plans. Provide a maintenance walkway that extends from the DMS inspection door to 3 feet (0.9 meter) over the edge of shoulder. Position the walkway so that there is no opening greater than 10" (254mm) that is unprotected. Provide walkways with fixed safety railings along both sides from the beginning of the walkway to the inspection door. When not in use, the safety railing may remain in a permanent upright position.

Connect the walkway sections rigidly where sections join to avoid an uneven walking surface. Attach the walkway directly to the walkway brackets.

Install a 4"x 4" (100 mm x 100mm) safety angle parallel to and along both sides of the walkway and extend it the entire length of the walkway. Design the safety angle to withstand loading equivalent to the walkway.

Provide a walkway in which the open ends have a galvanized steel coil safety chain attached on one end near the top of the safety railing, and on the other end to the walkway hanger, or other fixed member of the structure.

If Signing Plans requires a pedestal type structure, provide a three feet wide landing area leading to one of the DMS inspection door as approved by the Engineer. The length of the landing area must be four feet or the width of the DMS inspection door plus 1.5 feet, whichever is greater. Protect the landing area with safety handrails on both sides.

3. Footings for Dynamic Message Sign Assembly

Design footings for the combined effects of dead and wind loads; use either spread type or pole type as specified in the project plans. Design spread footings for a maximum soil bearing of 3 ksf (145 KPa) unless otherwise allowed by the Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals. If, in the judgment of the Engineer, the soil in a given footing excavation is not adequate for 3 ksf (145 KPa) bearing pressure, or any other bearing pressure noted on approved footing drawings, the Contractor may be required to change his footing design to meet actual soil conditions at no cost to the Department.

Perform all excavation and backfill necessary for footing construction to the elevations and dimensions shown in the plans or as directed by the Engineer.

Thoroughly compact all backfill in 6" (150 mm) layers. Remove all unneeded excavated material from the site.

Construct footing excavations for DMS assemblies that conform to the applicable provisions of Section 410 of the Standard Specifications. Make sure the sides of the excavation for pole type footings conform as nearly as practicable to the required dimensions. Place concrete for pole-type footings against undisturbed soil unless otherwise permitted by the Engineer. If, in the judgment of the Engineer, significant discontinuities in the required configuration of the excavation for pole-type footings are created by the removal of boulders or as a result of other causes, backfill the excavation and compact as provided for in Section 410. Re-excavate the

footings to the proper dimensions. The Engineer must approve shoring prior to use, if used to stabilize the sides of excavation for pole-type foundations.

Construct footings for DMS assembly in accordance with Section 825. Construct all footings of Class A concrete. Where rectangular forms are used, use forms with a chamfer strip at all corners for at least that distance protruding above ground level. Use a chamfer which measures 1" (25mm) along the diagonal face. Securely brace anchor bolts positioned in the form, and hold them in proper position and alignment. Provide a rubbed finish on concrete surfaces exposed above finished ground in accordance with Sub-article 825-6(D). Do not erect DMS assembly on footings until the concrete has reached a minimum compressive strength of 3000 psi (20.64 Mpa). Determine concrete compressive strength by non-destructive test methods, or by compressive strength tests made in accordance with AASHTO 2001, 4th edition. Furnish equipment used for non-destructive tests and obtain Engineer approval.

D. Location

The Engineer will establish the location of the DMS assembly longitudinally.

7.4 METHOD OF MEASUREMENT

The work covered by this section includes all design, fabrication, construction, transportation, and attachment of the complete dynamic message sign assembly, supporting structure, hardware, maintenance walkway, footings, direct tension indicators specified in the section titled "DMS Direct Tension Indicators", preparing and furnishing shop drawings, additional documentation, incidentals, and all other equipment and features necessary to furnish the system described above.

7.5 BASIS OF PAYMENT

The Dynamic Message Sign Assembly, measured as provided above, will be paid for at the contract lump sum price per assembly for " Overhead Dynamic Message Sign Assembly "DMS ____"

Payment will be made under:

Overhead Dynamic Message Sign Assembly "DMS ____" .....Lump Sum

8. DMS DIRECT TENSION INDICATORS

8.1 GENERAL

Use direct tension indicators on all ASTM A325 high strength bolt connections in overhead and cantilever sign structures.

Provide direct tension indicators that conform to these Project Special Provisions, the requirements of ASTM F959 and the manufacturer's recommendations.

8.2 MATERIAL REQUIREMENTS

Use direct tension indicators whose material, manufacturing process, performance requirements, workmanship and certification requirements conform to the requirements of ASTM F959.

For Type 3 high strength bolts, use direct tension indicators mechanically galvanized to ASTM B695 Class 50, then with 1 mil of baked epoxy applied.

For plain Type 1 high-strength bolts, use direct tension indicators that are plain or mechanically galvanized to ASTM B695 Class 50.

For galvanized Type 1 high strength bolts, use direct tension indicators that are mechanically galvanized to ASTM B695 Class 50 only.

8.3 TEST DOCUMENTS

Furnish the Engineer with a copy of the manufacturer's test report for each lot of direct tension indicators used in the project. The manufacturer must perform these tests according to the requirements of ASTM F959. Include in each test report the lot number of the indicators, manufacturer's name, tension load when indicators were tested, gap clearance, nominal size, coating thickness, date tested, and name and location of the company that performed the tests.

Furnish the Engineer with a copy of the manufacturer's instructions for installing the direct tension indicators before installation begins along with at least 1 metal feeler gauge for each 50 direct tension indicators shipped.

Use only direct tension indicators whose container lot numbers match the lot numbers on the test documents.

8.4 REQUIRED TEST SAMPLES

Furnish the Engineer with three samples of load indicating washers from each lot number, size and type for departmental tests along with two of the metal feeler gages required for performing the tests.

8.5 CONSTRUCTION METHODS

A. Installation

Install the direct tension indicators in strict compliance with the manufacturer's written instructions.

Install the direct tension indicator under the bolt head normally. If it is necessary to install the direct tension indicator under the nut, or if the bolt head must be turned, install additional hardened washers in accordance with the manufacturer's instructions.

Have a tension-indicating device on the project for determining the tension imposed on a fastener when the protrusions on direct tension indicator have been properly compressed.

Test three samples from each lot of direct tension indicators in the presence of the Engineer. Achieve a minimum bolt tension 5 percent greater than that required by Table 440-1 in Article 440-10 of the Standard Specifications. Do not substitute direct tension indicators for the hardened steel washers required with short slotted or oversized holes, but you may use them in conjunction with them.

Initially install the direct tension indicators to a snug tight condition as specified in Section 440-10 Paragraph (C) (3) of the Standard Specifications. After the initial tightening, fully tighten the fasteners, as recommended by the manufacturer of the direct tension indicators, beginning at the most rigid part of the joint and continuing toward its free edges.

Use a wrench to tighten fasteners containing direct tension indicators of the type and capacity recommended by the manufacturer and which is clean and lubricated. Use an air supply and hoses that are in good condition and provide air pressure of at least 100 psi (690 KPa) at the wrench.

Perform any heating of structural steel required for corrections in the vicinity of fasteners before direct tension indicators are installed.

B. Inspection

The Engineer will inspect for correct tightening of bolts by inserting a 0.005" (0.125 mm) thickness feeler gauge into the openings between adjacent flattened protrusions of the direct tension indicator. The tension is correct when the number of spaces the gage can not enter is equal to or greater than the value shown in the table below.

Number of Spaces in Washer	Number of Spaces Gage is Refused
4	2
5	3
6	3
7	4

The gage must not be able to enter any spaces when the direct tension indicator is used under the turned element.

Do not tighten bolts to a no visible gap condition. Replace bolts that have a direct tension indicator with no visible gap and tighten the bolts with a direct tension indicator.

The Engineer will inspect at least 10 percent, but no less than 2, of the bolts in each connection, using the metal feeler gages provided by the Contractor.

Ensure that the part of the fastener being restrained from turning does not rotate during the tightening process, thereby abrading away a portion of the direct tension indicator protrusions.

Ensure that none of the direct tension indicator protrusions are accidentally partially flattened before installing in the structural steel joints.

Do not reuse direct tension indicators. If it becomes necessary to loosen a bolt previously tensioned, discard and replace the direct tension indicator.

8.6 METHOD OF MEASUREMENT

There will be no direct payment for the work covered by this section.

Payment for this work will be covered in the applicable sections of these Project Special Provisions at the contract unit price for "Overhead Dynamic Message Sign Assembly "DMS ____" and will be full compensation for all work listed above.

9. TRAINING

9.1 DESCRIPTION

Provide training courses covering the operation and maintenance of the equipment being supplied as part of the system. Train Department personnel to properly operate, maintain, and troubleshoot each piece of equipment and software within the system. Provide training for a minimum of fifteen (15) Department personnel. Provide training for DMS operation, troubleshooting, and repair. Provide training for each of the following categories and for the minimum number of hours shown:

DMS operation ..... 4 Hours

DMS troubleshooting and repair ..... 12 Hours

Each category shall consist of demonstration and hands-on activities. All training courses shall be conducted at a Contractor provided location within the time mutually agreed upon by the Engineer and the Contractor. Provide documentation for up to 15 attendees. Provide 15 copies of the approved course materials at least 14 days in advance of the scheduled course. Training course shall not exceed 8 hours on any given day.

9.2 MATERIAL

The Contractor shall provide qualified instructors and training material in order to present formal classroom as well as "hands-on" user training in the operation, maintenance, and troubleshooting of the equipment being supplied as part of the system. Manufacturer's representatives, or personnel approved by the Engineer, shall conduct the training course. Particular attention shall be given to precautions that must be observed in operating the equipment. Training courses shall be required for both the control center elements and field elements of the system.

The training material generated for each course shall contain "hand-outs" for each attendee, which shall serve not only as subject guidance, but also as quick reference material for future use by the students. All course material, in reproducible form, shall be delivered to the Engineer immediately following course completion. In addition to on-site training, provide the required training on VHS videotape. All tape shall be labeled, noting at a minimum the date of the course and title of the course.

At least 40 days prior to commencement of the training course submit to the Engineer detailed course curricula, draft manuals and materials, and resumes of the instructor(s). Provide training for each of the following categories and for the minimum number of hours shown:

DMS..... 16 Hours

Address the following topics as a minimum:

- Theory of operation
- Installation
- Operation
- Preventative maintenance of equipment
- Trouble shooting and equipment diagnostics

- Integration of equipment with field hardware, central hardware, and software components.

9.3 METHOD OF MEASURMENT

This work shall include providing instructors, visual aid materials, documentation materials, VHS video taping of courses and other items required for the specified training. The work shall also include, but not be limited to, furnishing all labor, instructional materials (including sample equipment), room rental, transportation and expenses of Contractor personnel and providing other incidentals as necessary to prepare and conduct the training sessions.

9.4 BASIS OF PAYMENT

Payment will be made under:

Dynamic Message Sign Maintenance Training.....Lump Sum

10. SYSTEM SUPPORT EQUIPMENT

10.1 DESCRIPTION

Furnish system support equipment with all necessary hardware in accordance with the plans and specifications.

10.2 MATERIAL

A. General:

Furnish equipment with test probes/leads, batteries (for battery-operated units), line cords (for AC-operated units), and carrying cases. Provide operating instructions and maintenance manuals with each item.

Prior to starting any system testing or training, furnish all system support equipment.

B. System Support Equipment:

Furnish new, unused system support equipment to the Engineer in the quantities shown below:

- One (1) DMS Controller

10.3 METHOD OF MEASUREMENT

Actual number of DMS Controllers furnished and accepted.

10.4 BASIS OF PAYMENT

The quantity of DMS Controllers, measured as provided above, will be paid for at the contract unit price each for "Furnish DMS Controller".

Payment will be made under:

Furnish DMS Controller ..... Each