STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

REQUEST FOR QUALIFICATIONS

350-18-016

Project Specifications and Instructions
for Submitting a Response to

Qualified Dynamic Message Sign Manufacturer Selection and Equipment Qualifications Testing

Statewide

Due: **August 8, 2019**
No later than 11:00 A.M. PT

Kristina Swallow, P.E., Director
Department of Transportation

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ATTACHMENTS

This Request for Qualifications (RFQ) is being advertised to select two (2) prospective manufacturers who manufacture Dynamic Message Sign (DMS) equipment; can provide DMS assemblies that meet or exceed the requirements identified in the Nevada Department of Transportation ("DEPARTMENT") 2018 Specifications for Full Color and Amber Matrix LED Dynamic Message Signs; and can successfully pass DMS equipment Qualifications Testing (QT) for the DEPARTMENT's DMS Qualified Product List (QPL) of equipment that can be installed along Nevada roadways and integrated as part of the DEPARTMENT's Intelligent Transportation System (ITS) infrastructure. Issuance of this RFQ shall in no way constitute a commitment by the DEPARTMENT to execute an Agreement or place products on the DEPARTMENT's DMS QPL.

The DEPARTMENT reserves the right to issue addenda to this RFQ prior to the closing date. It is the Firm's responsibility to check for any addenda to this procurement at www.nevadadot.com prior to submission. Submission of Statements of Qualifications constitutes acknowledgement of this RFQ and all subsequent addenda. The DEPARTMENT reserves the right to reject any or all submissions received in response to this RFQ, or to cancel this RFQ if it is deemed in the best interest of the DEPARTMENT to do so.

SECTION I - BACKGROUND

The DEPARTMENT currently has an existing DMS QPL that includes one (1) type of DMS product comprised of amber Light Emitting Diode (LED) DMS technology. The DMS industry has advanced in abilities including DMS with full color and full matrix. The DEPARTMENT would like to prequalify manufacturers to provide DMS products. The DEPARTMENT has used the existing DMS QPL for the last 14-years for Contractors to select from for procuring DMS equipment for installation on DEPARTMENT projects. With the DMS QPL, the Contractors know what DMS products are pre-approved for use and the Contractors procure the DMS equipment and services directly from the DMS manufacturers on the DMS QPL. The products and services that the DMS manufacturers provide to the Contractors, and in some cases directly to the DEPARTMENT, are as specified in the DEPARTMENT's DMS specifications.

The DEPARTMENT has recently updated the DMS specifications to include both amber and full color LED DMS technology and has made other types of changes to the specifications for improvement. Using the new DMS specifications (Exhibit 1, the 2018 Specifications for Full Color and Amber Matrix Led Dynamic Message Signs) and this RFQ, the DEPARTMENT will approve listings on the new DMS QPL comprised of products from two (2) manufacturers for the Contractors to select from on DEPARTMENT Projects.

SECTION II - MINIMUM QUALIFICATIONS

Statement of Qualifications (SOQ) will first be reviewed to determine if minimum qualification requirements are met. Qualifications will be evaluated solely based upon information submitted in the SOQ; therefore, the SOQ must include sufficiently detailed information to clearly establish that the Firm meets the minimum qualifications. Any submittals that do not meet the minimum qualification requirements, as outlined below, will be disposed of in an appropriate manner, at the sole discretion of the DEPARTMENT, and without further review. All minimum qualifications must be held at time of submittal unless otherwise indicated.

Minimum Qualification Requirements:

1. Firms must currently manufacture DMS equipment and can provide DMS assemblies and services that meet the requirements of Exhibit 1, the 2018 Specifications for Full Color and Amber Matrix Led Dynamic Message Signs.

2. Firm shall have a minimum of five (5) years of experience in manufacturing DMS assemblies.

3. Firms shall provide full matrix LED DMS, including both full color and amber type signs, that are within the following structural parameters of the DEPARTMENT's standard DMS overhead sign structure details:

   Non-Walk-In DMS

	Type 1	Type 2
Parameter	**Maximum**	**Maximum**
Outside length of sign housing	28.25 ft.	12.16 ft.
Outside height of sign housing	8.0 ft.	6.16 ft.
Outside depth of sign housing	1.5 ft.	1.5 ft.
Sign housing weight with all contents	4000 lbs.	900 lbs.

   Walk-In Access DMS

	Type 1
Parameter	**Maximum**
Outside length of sign housing	28.25 ft.
Outside height of sign housing	8.0 ft.
Outside depth of sign housing	48.0 in.
Sign housing weight with all contents	4,000 lbs.

SECTION III - INSTRUCTIONS

Task	Date
Advertised	07/11/2019
Firms' Questions Due	**07/18/2019** at 11:00 A.M. PT
DEPARTMENT's Response to Firms' Questions Distributed	07/25/2019
Submittal Due	**08/08/2019** at 11:00 A.M. PT

The Submittal must respond to each Evaluation Factor, listed in the exact order below. Provide clearly titled sections, referencing the same number and title as the Evaluation Factor being addressed.

No cost information is to be provided with the submission. The selection will be based on the Firm offering the best qualifications to the DEPARTMENT.

EVALUATION FACTORS

1. **Quality & Compliance (25 points):** Provide the following information:
   a. Provide a conformance statement with written assurance that states the DMS assemblies currently meet, or will meet, the specified requirements of NEMA TS 4-2016 and the 2018 NDOT Dynamic Message Sign Specification. Clearly identify any items within the specification requirements that are currently not met by the products being proposed and provide the date that the manufacturer is committing to achieve each of these requirements.

b. Provide documentation that demonstrates conformance to the requirements of NEMA TS 4-2016, including but not limited to, a description of the test article and a copy of the table in section 11.5 of the NEMA TS 4-2016 which clearly identifies which mandatory and minimum requirements are currently met with the product(s) proposed. (documentation can be referenced and placed in an appendix)
c. Provide an ISO 9001 certificate, or some other means of demonstrating compliance with a quality assurance model that is similar to ISO 9001. (certificate can be referenced and placed in an appendix)
d. Provide proof of certification of all the LED DMS manufacturer's welders and applicable welding procedures, if welding is used. If welding is not used, acknowledge the lack of welding. (proof can be referenced and placed in an appendix)

2. **Qualifications and Experience (20 points):** Provide the following information:
   a. Describe your years of experience in manufacturing DMS assemblies within the United States. All Firms shall provide information describing their experience with similar projects. Firms shall also describe their roles in these projects (e.g., manufacturer, integrator, equipment installer, equipment training, maintenance services, etc.).
   b. Describe three (3) projects, each for different customers, where similar size and type DMS assemblies were provided and successfully installed within the last five (5) years.
   c. Three (3) References - Provide a minimum of three (3) references of customers that the manufacturer has provided DMS assemblies to in the past. References from customers that have deployed DMS in hot desert climates and high elevation cold climates are preferred, as well as, government/municipal type customers and customers that have had the manufacturer's DMS deployed for five (5) or more years within the United States. Include the following minimum information:
      i. Name and model number of the DMS and Sign Controller Unit (SCU) provided and the approximate date they were installed
      ii. Location where the DMS and SCU was installed
      iii. Name of the agency or entity that currently owns and maintains the DMS and SCU
      iv. Name of the contact person that currently works for the agency or entity and the contact information (telephone number and email address) for this person.
   d. Litigation – Firms shall provide a description of any litigation and resolutions in the past five (5) years related to Firm's work or work product and provide a copy of a letter from the Firm's attorney and/or in-house legal counsel concerning the status of lawsuits and pending litigation for the most recent year.

3. **Warranty, Product Life Span, and Service (20 points):** Provide the following information:
   a. Provide a statement acknowledging the warranty, DMS minimum service life, and spare parts and service requirements identified within the 2018 Specifications for Full Color and Amber Matrix Led Dynamic Message Signs.
   b. Provide a description of how the manufacturer intends to meet or exceed the warranty, DMS minimum service life, and spare parts requirements.
   c. Provide a description of the manufacturer's approach, customer service procedures, and commitment to the DEPARTMENT for providing technical support, bench level repair services for failed components, and stocking of parts for replacement for the required life span of the sign. Provide details for how long parts and service will be provided to the DEPARTMENT for all equipment being supplied for DEPARTMENT use. Provide this information in the form of a service guarantee.
   d. Provide a description for preventative maintenance that should be performed and the schedule for these activities.
   e. Provide a description for how the manufacturer's design and manufacturing approach supports the ability to upgrade the DMS equipment, firmware, and software as technology advances, while maintaining backwards compatibility with existing components to remain.
   f. Clearly describe all limitations to the warranty, product life span, and services being offered.
   g. Provide a list of manufacturer serviceable components, which are components with less than the required DMS design life.

h. Provide a description of the manufacturer financial stability. (this can be referenced and placed in an appendix)

4. **Proposed Products (15 points):** Provide the following information:
   a. Provide a statement acknowledging the 2018 Specifications for Full Color and Amber Matrix Led Dynamic Message Signs requirements and commitment to meet or exceed those requirements.
   b. Provide a summary table of products proposed (Type 1 & 2, walk-in/non-walk-in, color/amber) with the maximum wattage for each sign type. The maximum wattage value shall include all components within and on the sign housing and within the controller cabinet, with 100% of all pixels illuminated, at full intensity, with ventilation system and heaters running.
   c. Provide LED and Pixel Characteristics documentation describing the method used by the Provider to achieve the specified requirements.
   d. Provide detailed shop drawings and recommended installation methods on existing NDOT DMS structures. (drawings can be referenced and placed in an appendix)
   e. Provide SCU cabinet drawings and rack layout diagrams. (drawings and diagrams can be referenced and placed in an appendix)
   f. Provide the maximum distance (i.e., cable run distance) between the SCU and the DMS housing for each proposed DMS.
   g. Provide a power wiring diagram for each DMS assembly being proposed that clearly identifies all components that are connected to each of the two 120VAC phases and which loads are connected using 240VAC from the utility service feeder. (wiring diagrams can be referenced and placed in an appendix)
   h. Provide a load summary table, for each DMS assembly being proposed, showing the individual loads of each component, a subtotal of the power load on each 120VAC phase, and the overall power load for the 120/240VAC feeder circuit.
   i. Provide a description of how the proposed products achieve the pixel control wiring redundant power supply requirements in the specification.
   j. Provide a summary description of any other types of redundancy that may be offered in the proposed products.
   k. Provide the specifications used by the Firm for defining the DMS assembly character sets.

5. **Availability and Capacity (15 points):** Provide the following information:
   a. Provide a description of the manufacturer's staffing capacity for customer service and technical support.
   b. Provide a description of the manufacturer's capacity to handle multiple orders for new DMS. Include the anticipated lead time required for placing an order (i.e., the typical time it will take for the manufacturer to deliver a new DMS after an order is placed).

6. **Other Factors (5 points):** Provide the following information:
   a. Description of how the proposed products are superior to other products in the industry, if applicable.
   b. Provide photographs of the proposed DMS models and SCU cabinets. (photographs can be referenced and placed in an appendix)
   c. Provide user/operations and maintenance instruction manuals. (manuals can be referenced and placed in an appendix)
   d. Describe any security provisions that may be included in the product offerings.
   e. Provide any additional documents to further describe equipment included in DMS assemblies or SCU cabinets being proposed. (documents can be referenced and placed in an appendix)

The Firms must follow these requirements in preparing their Submittals:

1. The Firm must respond to each Evaluation Factor. Each response must be contained in its own unique, numbered section bearing the same number and title as the particular Evaluation Factor being addressed and presented in the exact same order as the Evaluation Factors appear in Section IV - Instructions.

2. The responses to the Evaluation Factors including tables must be 1.5-line spacing and must use no smaller than 11-point font.

3. The Cover Letter must be single-spaced and must not exceed one (1) 8½" x 11" page. It must include the Firm's contact information including name, mailing address, telephone number, and email address.

4. Resumes, Nevada State Business Licenses and Statements of Qualifications (see Attachment A - Statement of Qualifications), must only be included as an Appendix to the Submission.

Failure to meet the above stated requirements and limitations may result in a submission being deemed non-responsive in the DEPARTMENT's sole discretion.

The submission must be sent via email to agreeservices@dot.nv.gov as a Portable Document Format (PDF) **NO LATER THAN 11:00 A.M., on August 8, 2019,** with the e-mail subject line addressed ***exactly*** as follows: **Request for Quote for Qualified Dynamic Message Sign Manufacturer Selection and Equipment Qualifications Testing**.

Submissions received after the specified deadline **will not** be considered and will be disposed of in an appropriate manner suitable to the DEPARTMENT, in its sole discretion.

Confidential Information, Trade Secrets, and/or Proprietary Information must be marked as such in the Submittal. The failure to mark this information as per NRS 333.020 and 333.333 shall constitute a complete waiver of any and all claims for damages caused by release of the information by the DEPARTMENT. If the DEPARTMENT reviews the confidential information and determines that the information is not considered confidential pursuant to NRS Chapter 333, the DEPARTMENT will contact the Firm. The Firm must advise the DEPARTMENT as to whether it either accepts the DEPARTMENT's determination that the information is not confidential or withdraws the information. The Firm will not be allowed to alter the Submittal after the date and time set for receipt of Submittals shown above. Notwithstanding the provisions in NRS Chapter 333, the DEPARTMENT retains its immunity pursuant to the provisions of NRS 239.012 for any "good faith" release of information, and the immunities from liability provided to it pursuant to NRS Chapter 41.

The DEPARTMENT assumes no financial responsibility in connection with the Firms' costs incurred by attending the pre-submittal meeting if required, in the preparation and submission of the Submittal packets, or by attending the oral interviews, if such interviews are conducted by the DEPARTMENT in its sole discretion.

SECTION IV - RULES OF CONTACT

The following rules of contact shall apply during this procurement:

After release of the RFQ and through the Notice of Intent to accept the Firms' qualified product, the Firms shall **ONLY** correspond with the DEPARTMENT regarding this RFQ through the DEPARTMENT's designated representative as per NAC 333.155. The designated representative's contact information is:

Agreement Services
Nevada DEPARTMENT of Transportation
1263 South Stewart Street, Room 102
Carson City, Nevada 89712
Phone: 775-888-7070, Option 1
Fax: 775-888-7101

agreeservices@dot.nv.gov

The Firms shall not contact the DEPARTMENT's employees, including DEPARTMENT heads, members of the review committee and/or any official who will participate in the decision to accept the Firms' qualified product, except through the process identified above. Any communications determined to be improper may result in disqualification, at the sole discretion of the DEPARTMENT. Any official information regarding the RFQ will be disseminated by the DEPARTMENT. Specific information necessary for the preparation of Submittals will be disclosed to all Firms. The DEPARTMENT will not be responsible for any oral exchange or any other information or exchange that occurs outside the official process specified herein. Failure to comply with these rules of contact may result in a Submittal being deemed non-responsive in the DEPARTMENT's sole discretion.

SECTION V - FIRM QUESTIONS

Any irregularities or lack of clarity in the RFQ must be brought to Agreement Service's attention, in writing, as soon as possible, so that corrective addenda may be furnished by the DEPARTMENT in a timely manner to all Firms.

Any questions raised must be submitted in writing to Agreement Services, via email, to agreeservices@dot.nv.gov, or faxed to (775) 888-7101, and received by **11:00 A.M.**, **on July 18, 2019**. Written responses will be distributed by the DEPARTMENT on or before July 25, 2019.

SECTION VI - NEVADA BUSINESS LICENSE REQUIREMENT

The selected manufacturer, prior to doing business in the State of Nevada, must be appropriately licensed by the Office of the Secretary of State pursuant to NRS 76.100. Information regarding the Nevada State Business License can be located at www.nvsos.gov.

Before the Agreement(s) resulting from this RFQ can be executed, the successful Firm(s) must provide the following:

A. Nevada State Business License Number; and

B. Business Entity's Legal Name (affirm that it is the same name under which the Firm is doing business).

Additionally, if the Firm is a corporation, LLC, LP, LLP, or LLLP, or non-profit corporation based out of state, it must be registered as a foreign business entity equivalent in Nevada, in active status, and in good standing with the Nevada Secretary of State.

Each Firm shall clearly state, at the time of submission, its willingness to adhere to this requirement by providing a statement of adherence within the cover letter, a copy of its Nevada State Business License, a copy of its application from the Secretary of State Office, or a print out of the entity status, which can be obtained from the Nevada Business Search found on the homepage of the Nevada Secretary of State's website at www.nvsos.gov.

To apply for a Nevada State Business License or to file appropriate formation documents with the Nevada Secretary of State's office, please visit www.nvsos.gov. Business licenses can be obtained immediately by applying on-line; however, paper applications may take several weeks to process.

SECTION VII - SELECTION PROCESS

Selection will be based on the Evaluation Factors listed in the Evaluation Factors section (Section IV), which will be used by a Review Committee to evaluate the submissions. The Review Committee will be

comprised of DEPARTMENT staff, consultant team, and may include other members representing local entities, who shall remain anonymous to protect the integrity of the procurement process.

The committee may use the information submitted in the Firms' Submittal package, the information referenced in this RFQ, and the information presented at the interview, if applicable, to arrive at the final ranking. The Submittals will be ranked and the two (2) most qualified Firms will be selected to proceed with the Qualifications Testing (QT) phase of the selection process (see Attachment B - Qualifications Testing for more information). If one or more of the two (2) most qualified Firms cannot pass the QT for an acceptable group of products that they proposed, the DEPARTMENT, in its sole discretion, may proceed with the QT phase of the selection process with the next highest ranked manufacturer, and so on, until an acceptable group of products from two (2) manufacturers successfully pass QT for placement on the DMS QPL. If only one (1) manufacturer's products successfully pass QT the DEPARTMENT, in its sole discretion, may elect to place that manufacturer's products on the DMS QPL or may elect to terminate the solicitation.

SECTION VIII - TERMS, CONDITIONS AND EXCEPTIONS

This RFQ is being conducted in accordance with NRS Chapters 333 and 408, NAC Chapter 333, and SAM Section 300.

The DEPARTMENT reserves the right to alter, amend, or modify any provisions of this RFQ, or to withdraw this RFQ, at any time prior to the acceptance of a qualified product pursuant hereto, if, in the sole discretion of the DEPARTMENT, it is in the best interest of the state to do so.

The DEPARTMENT reserves the right to waive informalities and minor irregularities in Submittals received.

The DEPARTMENT reserves the right to reject any or all Submittals received prior to listing any products on the QPL.

Alterations, modifications or variations to a Submittal may not be considered unless authorized by the RFQ, or by an addendum or an amendment to the RFQ.

Submittals which appear unrealistic in the terms of technical commitments, lack of technical competence, or are indicative of failure to comprehend the complexity and risk of the requirements of this RFQ, may be rejected.

All materials submitted in accordance with the prescribed deadline become the property of the DEPARTMENT and will not be returned. The DEPARTMENT's selection or rejection of a Submittal does not affect this right. The master copy of each Submittal shall be retained for official files and will become public record after execution of an Agreement. Only specific parts of the Submittal may be labeled a "trade secret," provided that the Firm agrees to defend and indemnify the DEPARTMENT for honoring such a designation (NRS 333.333); unsuccessful Submittals containing "trade secrets" will be returned pursuant to NRS 239.010. The failure to so label any information shall constitute a complete waiver of any and all claims for damages caused by any release of such information by the DEPARTMENT. The DEPARTMENT shall not be liable for disclosure or release of information when authorized or required by law to do so pursuant to NRS 239.012.

Each Firm must disclose any existing or potential conflict of interest relative to the performance of the contractual services resulting from this RFQ. Any such relationship that might be perceived or represented as a conflict must be disclosed. By submitting a response to this RFQ, each Firm affirms that they have not given, nor intend to give at any time hereafter, any economic opportunity, future employment, gift, loan, gratuity, special discount, trip, favor, or service to a public servant or any employee or representative of same, in connection with this procurement. Any attempt to intentionally or unintentionally conceal or obfuscate a conflict of interest will automatically result in the disqualification of

a Firm's Submittal. A product acceptance will not be made where a conflict of interest exists. The DEPARTMENT, in its sole discretion, will determine whether a conflict of interest exists and whether it may reflect negatively on the DEPARTMENT's selection of a Firm. The DEPARTMENT reserves the right in its sole discretion to impose additional requirements upon the Firm to mitigate such conflict of interest or to disqualify any Firm on the grounds of an actual or an apparent conflict of interest.

The DEPARTMENT will not be liable for Federal, State, or Local excise taxes.

The Firm understands and acknowledges that the representations above are material and important, and will be relied on by the DEPARTMENT in its evaluation of a Submittal. **Any misrepresentation by a Firm shall be treated as fraudulent concealment from the DEPARTMENT of the true facts relating to the Submittal.**

No announcement concerning the Qualified Product Listing as a result of this RFQ can be made without the prior written approval of the DEPARTMENT.

The Nevada Attorney General will not render any type of legal opinion regarding this transaction.

ATTACHMENTS

Attachment A
Statement of Qualifications

RFQ-specific fillable PDF form is available as a separate document.

The Statement of Qualification form must be completed in full, as-is, and submitted as part of the Submittal package per Request for Qualifications instructions.

Request for Qualifications number: _____

Date prepared: _____

Manufacturer's name: _____

Minimum Qualification Requirements:

1. Does the Firm currently manufacture DMS equipment and can the Firm provide DMS assemblies and services, that meet the requirements of the 2018 Specifications for Full Color and Amber Matrix Led Dynamic Message Signs?

□ Yes □ No

2. Does the Firm have a minimum of five (5) years of experience in manufacturing DMS assemblies within the United States?

□ Yes □ No

Please list the relevant experience in manufacturing DMS assemblies:

3. Does the Firm currently manufacture DMS equipment and can the Firm provide full matrix LED DMS, including both full color and amber type signs, that are within the structural parameters that have been defined for the DEPARTMENT's standard overhead sign structure detail?

For Non-Walk-In DMS: □ Yes □ No

For Walk-In Access DMS: □ Yes □ No

Please provide the structural parameter information in the following table (i.e., areas indicated by the question mark) for the following types of products offered:

Non-Walk-In DMS

	Type 1 Amber DMS	Type 1 Full Color DMS	Type 2 Amber DMS	Type 2 Full Color DMS
Parameter	**Maximum**	**Maximum**	**Maximum**	**Maximum**
Outside length of sign housing				
Outside height of sign housing				
Outside depth of sign housing				
Sign housing weight with all contents				

Walk-In Access DMS

	Type 1 Amber DMS	Type 1 Full Color DMS
Parameter	**Maximum**	**Maximum**
Outside length of sign housing		
Outside height of sign housing		
Outside depth of sign housing		
Sign housing weight with all contents		

Attachment B
Qualifications Testing

1. General

The following Qualification Testing (QT) that shall be conducted prior to the listing of a DMS assembly product on the DEPARTMENT's Qualified Product List (QPL):

- Factory Demonstration Test (FDT)
- Communications Test (CT)

While these tests will be conducted during the QPL selection process, the DEPARTMENT reserves the right to also require one (1) or both of these tests be conducted during subsequent procurement projects. Approved test data forms shall be completed and submitted to the DEPARTMENT for review and approval after each of the above listed tests. Following the completion of a test, an authorized representative of the DEPARTMENT and the DMS Vendor shall sign all test data forms.

1.1 Test Procedures and Test Data Forms

The DMS Vendor shall prepare and submit test procedures and test data forms for the DEPARTMENT's approval at least thirty (30) working days before the scheduled testing as required. Test procedures shall be developed specifically in response to these requirements. Do not submit test procedures developed in response to other procurement documents, specifications or for other customers and projects. The DEPARTMENT will review submitted test procedures. At a minimum, the test procedures and data forms shall include the following:

- A step-by-step outline of the test sequence to be followed, showing a test of every function of the equipment or system to be tested. For each test, clearly identify in the test procedure the specific function or requirement being addressed.
- A description of the expected operation, output and test results
- An estimate of the test duration and a proposed test schedule
- A data form to be used to record all data and quantitative results obtained during the test
- A description of any special equipment, setup, manpower, or conditions required for the test

1.2 Test Equipment and Software

As part of the testing requirements, except as otherwise noted, the DMS Vendor shall be responsible for furnishing all test facilities, including DMS control software, required to complete the required testing. The DMS Vendor shall provide documentation and user instructions for use of any required test equipment and test software unless otherwise directed by the DEPARTMENT. DEPARTMENT representatives will provide Central System Software for tests.

2. Factory Demonstration Test

The FDT shall be conducted at the DMS assembly manufacturing facility. The purpose of the FDT is to demonstrate that the proposed DMS assembly meets all of the functional requirements defined in the specifications, including those specifically related to communications. The costs for lodging and transportation for two (2) DEPARTMENT staff members to make up to two (2) visits in order to witness this testing shall be borne by the DMS Vendor.

The DMS Vendor shall develop the test procedures that will govern this test and the DEPARTMENT shall review and approve these procedures. The DMS vendor shall obtain DEPARTMENT approval of the submitted test procedures prior to scheduling the testing dates. This testing shall be conducted using a DMS assembly production Sign Control Unit (SCU).

During this test, successful, reliable communication via each type of communication media specified in this document shall be demonstrated. For the FDT, the set-up shall include as a minimum, a SCU, a DMS and DMS control software running on a compatible desktop or laptop computer.

The DMS vendor shall provide the required communications infrastructure including modems, cabling and radios, etc. as well as all required computer hardware and software and all other ancillary equipment required to demonstrate that the DMS assembly communicates as specified.

Full compliance with the National Transportation Communications for ITS Protocol (NTCIP) Management Information Base (MIB) specified in NTCIP 1203 v3 shall be demonstrated using a NTCIP MIB test facility. This test shall demonstrate that the SCU communicates with all external computers (central servers and laptops) using the NTCIP MIB specified in NTCIP 1203 v3. The DEPARTMENT will provide the NTCIP test facility (exerciser) to be used during this test.

If multiple days are required to complete the FDT, it shall be conducted over consecutive workdays. The test procedure for the FDT shall clearly specify the number of days required to complete the FDT. The FDT shall be conducted in accordance with test procedures approved by the DEPARTMENT.

The FDT shall be conducted on a DMS assembly completely interconnected to represent the final field installation. The set-up shall include a sign, an SCU, a cabinet, a central computer, and a photoelectric sensing system.

If a component fails during the FDT, the component shall be corrected or replaced, and the test repeated until successful, as approved by the DEPARTMENT.

Except as otherwise noted, the DMS Vendor shall provide all other hardware, software and ancillary equipment required to test the DMS per approved FDT test procedures.

At a minimum, the FDT shall verify the following:

- Memory requirements
- Downloading and editing
- Placing messages in memory buffer and confirming content
- Display of all characters on the sign for each defined font and standard Manual of Uniform Traffic Control Devices (MUTCD) graphics
- Display of all possible message types (including static, flashing and alternating) on the sign
- Display of a message from each message slot in the memory buffer
- No loss of RAM memory during a 24-hour power outage
- Normal sign display operations during uploading and downloading
- The display of the longest possible message within the specified time requirements
- Readability
- Display of two-phase flashing messages of maximum characters per phase
- Display of two-phase steady messages of maximum characters per phase
- Adjustment of display light levels
- Selection of messages from SCU via the integral control keyboard without the laptop or central computer
- Message writing and erasing by column scan
- Electrical power requirements
- Resumption of specified operation after interruption of electrical power
- Operator selectable display items
- Activation of all pixels at selectable intervals
- Acceptance of commands from central system software, DMS control software laptop computer and integral control panel
- Required failure detection

- Required failure reporting
- Dimming and over-bright modes and photoelectric switch operation
- Downloading of messages to the sign controller and commanding of the display of each downloaded message on the sign
- Isolation of failed sign elements by the SCU without the use of any auxiliary equipment. Failed pixels shall be reported in real-time to the SCU where an LED display will indicate failures without the use of test equipment. For the non-dial-up communication case, demonstrate that failed pixels shall be reported to the central system at the next polling cycle. For the dial-up communication case, demonstrate that the SCU will initiate a call to central to report the failed pixels to the central system and that the SCU shall retry sending the failed pixel report to central for a user-settable number of times; and at a user-settable periodicity.
- Verify mechanical, dimensional, and assembly conformance of all parts to those specifications that can be checked visually or manually with simple measuring devices.
- Verify door open alarms for the SCU cabinet and sign housing
- Required operation during power line transients
- Intensity and chromaticity requirements
- Heating and ventilation system requirements
- UPS operational requirements

2.1 Readability

This test shall be conducted using five (5) individuals with 20/20 corrected vision, optionally selected by the DEPARTMENT. Messages shall be read at distances of 200 feet and 1,000 feet, with the sun at a low angle both in front and behind the sign. Eighty-percent (80%) correct response shall be considered passing.

2.2 Power Line Transient Test

A transient generator shall be connected to the AC input service of the SCU and test pulses applied under the following conditions:

a. With power to the SCU assembly turned off, apply 1000 volts of both positive and negative polarity to the AC input every two (2) seconds for a maximum of three (3) applications of each polarity. The energy source shall be a fully charged 15 microfarad capacitor.

b. With power to the SCU turned on and the sign display continuously (every three (3) seconds) responding to commands for new messages from the communications unit, apply tests pulses as follows:

   - Amplitude - 300V both positive and negative polarity
   - Peak power - 2500 watts

   Repetition – one (1) pulse approximately every other cycle moving uniformly over the full wave in order to sweep over the line cycle once every three (3) seconds.

   - Pulse rise time - 1 microsecond
   - Pulse width - 10 microseconds

   These pulses shall cause no noticeable effect on the proper operation of the sign display.

c. With power to the sign controller turned on and the sign display continually (every three (3) seconds) responding to commands for new messages from the communications unit apply test pulses as follows:

   - Amplitude - 600V both positive and negative polarity

- Energy source – oil-filled, 10 microfarad capacitor with internal surge impedance of less than 1 ohm
- Repetition – one (1) discharge every ten (10) seconds randomly across 360 degrees of the line cycle

These pulses shall cause no noticeable effect on the proper operation of the sign display.

2.3 Intensity and Chromaticity

Tests shall be conducted to verify chromaticity and intensity over the temperature spectrum. Seven (7) states shall be tested to simulate this condition. They shall include night (approximately 0.2 ft candles), low light (a normally lit office), over-bright (bright sunlight) and four (4) additional light settings approved by the DEPARTMENT. The tests shall be repeated at two (2) temperatures separated by the test day's low and high temperatures or 20° F, whichever is greater.

3. Communications Test

The CT shall be conducted using a DMS assembly production SCU unit to demonstrate that all communication requirements of this specification are satisfied. The CT shall be conducted over consecutive workdays. The test procedure for the CT shall be developed by the DMS vendor and approved by the DEPARTMENT.

The CT shall be conducted on a DMS assembly SCU interconnected in a manner that represents a final field installation. Successful communication via each type of media communication specified herein shall be demonstrated. The set-up shall include a SCU, a DMS or a display mock-up, and central software running on a compatible desktop or laptop computer.

At a minimum, the CT shall verify the following:

- Downloading and uploading of messages
- SCU sends a response to central for only messages containing its own unique address
- Commanding from central of the display of messages stored in the sign
- Failures shall be reported to the central system upon the next poll following the failure occurrence.
- Setting of the SCU clock via the central computer.
- Proof of compatibility with the communications protocol
- For non-dial-up configurations, the SCU sends a response message to central only in response to messages containing its own unique address
- Prevention of data corruption as a result of the central computer attempting to send improper data
- Remote reset of the SCU including a check of RAM and display memory
- Setting of the SCU clock via the central computer or laptop

Attachment C
Submittal Preparation Instructions

Submission

- Submitted no later than 11:00 A.M. PT on **August 8, 2019**
- Must be submitted via email to agreeservices@dot.nv.gov as a Portable Document Format (PDF) with the e-mail subject line addressed ***exactly*** as follows: **Request for Quote for Qualified Dynamic Message Sign Manufacturer Selection and Equipment Qualifications Testing**.
- Clarifying questions submitted in writing to Agreement Services, via email to agreeservices@dot.nv.gov, and received by **11:00 A.M.**, on **July 18, 2019**.

Submittal Format

- Font size no less than 11 point (this page is Arial font size 11)
- Line spacing including tables is 1.5-spaced
- Ordered according to Evaluation Criteria

Submittal Content

- Cover Letter not exceeding one (1) 8½" x 11" page, containing Firm's name, mailing address, telephone number, and email address
- Sections addressing each of the Evaluation Criteria in the following order:
  - Quality and Compliance
  - Qualifications and Experience
  - Warranty, Product Life Span, and Service
  - Proposed Products
  - Availability and Capacity
  - Other Factors
  - Appendices containing:
    - Resumes
    - Nevada State Business License
    - Statement of Qualifications (SOQ) (Attachment B)
    - Professional Engineer's License

Confidential Information, Trade Secrets, and/or Proprietary Information clearly marked "Confidential."

Attachment D
Title VI Compliance Questionnaire

Title VI is a statute provision of the Civil Rights Act of 1964:

> "No person in the United States shall, on the grounds of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." (42 USC Sec 2000d)

The following information will be used by the Nevada DEPARTMENT of Transportation (DEPARTMENT) and the Federal Highway Administration (FHWA) for statistical purposes only. This information will be stored confidentially, and will not affect any decisions made by the DEPARTMENT.

Your participation is voluntary, but would be greatly appreciated. If you choose to participate, please do not include this form with your Submittal. Please upload this questionnaire to the Confidential folder provided in EPATS.

Choose one ethnic group with which the principal owner(s) most identify:

- ☐ **Black** (Not of Hispanic origin: All persons having origins in any of the Black racial groups.)
- ☐ **Asian/Pacific Islander** (All persons having origins in any of the original peoples of the Far East, Southeast Asia, the Indian Subcontinent, or the Pacific Islands. This area includes, for example, China, Japan, Korea, the Philippine Islands, and Samoa.)
- ☐ **Hispanic** (All persons of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture or origin, regardless of race.)
- ☐ **Native American** (All persons having origins in any of the original peoples of North America and who maintain cultural identification through a tribal affiliation or community recognition.)
- ☐ **White** (Not of Hispanic origin: All persons having origins in any of the original peoples of Europe, North Africa, or Middle East.)
- ☐ **Other** (All persons not matching one of the other choices.)

Sex: ☐ Male ☐ Female

☐ I understand my participation is voluntary and decline to provide the requested information

Manufacturer Name:_____

Owner Name (Print):_____

Owner Name (Sign):_____

Date:_____

THE NEVADA STATE

DEPARTMENT OF TRANSPORTATION

2018 Specifications for:

FULL COLOR AND AMBER MATRIX LED

DYNAMIC MESSAGE SIGNS

September 2018

Table of Contents

1. DESCRIPTION

This standard specification outlines the minimum qualifications for Full Matrix LED Dynamic Message Sign (DMS) assemblies, materials, DMS software requirements and DMS testing requirements. The DMS Displays shall fit the size configurations as specified in this document and be solid state. No mechanical or electro-mechanical elements or shutters shall be used. The DMS Sign Controller Unit (SCU) shall be fully compatible with the most up-to-date NDOT Central System Software including the Nevada-MIB (Appendix B) and NTCIP MIB provided in NTCIP 1203 v3. Sign manufactures must support minimum SNMP v2 to maintain communication capability with NDOT Central System Software.

The Full Matrix LED DMS assembly types shall be capable of supporting MUTCD graphics in messages and multiple lines of text at different text heights. The display of graphics shall conform to NTCIP 1203 v3 standards. DMS assembly shall be constructed so they can be adapted for installation on a new or existing single pole structure (top or cantilever mount), overhead truss (two pole) or fixed structure (bridge, wall, etc.). The structures shall be referenced from the Standard Plans for Road and Bridge Construction, State of Nevada Department of Transportation 2017 Details T-36.2.1 to T-36.2.10 and Details T-36.4.1. Structural details are found in Appendix A.

This standard specification defines qualifications for the below sign types:

	Type	Walk-In	Non Walk-In	Maximum Pitch	
Amber	Type 1-AW	X		70 mm	(max or smaller)
	Type 1-A		X	70 mm	
	Type 2-A			70 mm	
	Type 3-A		X	70 mm	
Full Color	Type 1-CW	X		20 mm	(max or smaller)
	Type 1-C		X	20 mm	
	Type 2-C		X	20 mm	
	Type 3-C		X	20 mm	

Table 1: DMS Sign Types

Specifics of sign types will be covered subsequently.

The LED DMS legibility shall comply to the MUTCD Section 2L.04 Design Characteristics of Changeable Message Signs. Spacing between characters in a word shall be between 25 and 40 percent of the letter height and the spacing between words shall be between 75 to 100 percent of the letter height. Spacing between message lines and edge of sign face area shall be between 50 and 75 percent of the letter height. The stroke width-to-height ratio should be 0.2 and the width-to-height ratio for the sign characters shall be between 0.65 and 1 based off of the below requirements per sign type:

> **Type 1 (Color and Amber) -** The legibility of this sign shall exceed 1,000 feet when displaying three horizontal rows of text with a user-selectable number of 18 alphanumeric characters per row and with a nominal character height of 18 inches or as approved by the Department.
>
> **Type 2 (Color and Amber) -** The legibility of this sign shall exceed 750 feet when displaying three horizontal rows of text with a user selectable number of 12 alphanumerical characters per row with a nominal character height of 12 inches, or as approved by the Department.

The **Type 3 (Color and Amber)** signs shall vary in size and pixel pitch to meet varied needs of the department to support project specific applications which include but are not limited to the following types of signs:

- Variable speed limit signs
- Modular signs (an application where multiple smaller size signs are placed next to each other to create a single larger viewing area)
- Travel time signs
- LED display signs (potential application is a blank out sign)
- Other custom signs

All requirements outlined by this specification will be thoroughly inspected and tested by the Department. Failure to meet all details in this specification shall be grounds for rejection. All materials and equipment shall comply to the Standard Specifications for Road and Bridge Construction, State of Nevada Department of Transportation 2014 and as specified herein including but not limited to 106.12 Buy America.

1.1 DEFINITIONS/TERMINOLOGY

This section defines specific terms that apply to this special provision.

- **AIInGaP:** Aluminum Indium Gallium Phosphide. AIInGaP refers to the chemical composition of an Amber and Red LED dye.
- **Bin:** Group of LEDs categorized and sorted by intensity or color. Each bin has upper and lower intensity or color specifications, and it contains only LEDs that measure within that range. LED manufacturers sort LEDs into bins to ensure consistent intensity and color properties.
- **Candela (cd)**: A SI unit of measure for luminance.
- **Central Computer:** A computer system installed at a single location that is capable of controlling all DMSs in the system with one or more central computers operating on the central system software.
- **Control Cabinet:** A cabinet installed outside of the sign housing on the ground or attached to the sign pole that offers local access to the sign controller unit.
- **Default State:** A defined mode of operation that is assumed when other instructions are not given.
- **Display:** The message currently shown on the DMS face to the motorist.
- **Dynamic Message Sign (DMS):** Any sign system that can change the message presented to the viewer such as DMS, CMS, and VMS. It includes the following major components: sign face, sign housing, controller, and controller cabinet.
- **DMS Assembly:** Term used within this specification to refer to the DMS, SCU, SCU cabinet, DMS housing, housing support structure, DMS mounting brackets and hardware for connecting to the DMS overhead sign structures shown in the NDOT Standard Plans for Road and Bridge Construction structural details, control, power and communications cables, and all other components installed on, within and between the sign housing and control cabinet to create a complete and functional system.
- **DMS Controller:** A stand-alone sign controller located at a DMS site, which controls up to eight DMSs. The DMS controller receives commands and sends information to the central computer. Also known as the sign control unit (SCU).
- **DMS Housing:** The enclosure that environmentally protects the components of the DMS.
- **Font**: The style and shape of alphanumeric characters displayed on the LED panel matrix to create messages viewed by motorists and travelers.

- **InGaN:** Indium Gallium Nitride. InGaN is the semiconductor material used to make the dye for the green and blue LEDs**.**
- **Intensity:** The brightness of light emanating from the sign face, expressed in candela.
- **LED Panel:** The LED drive modules that are mounted on a static panel within the sign face. An LED panel does not contain components such as power supplies, fans, or heaters.
- **Message**: Information displayed on the sign face for the purpose of visually communicating with motorists.
- **LED Drive Module:** An assembly consisting of a 2-dimensional LED pixel array, pixel drive circuitry, and mounting hardware. Modules are installed adjacent to each other to form the display matrix.
- **Object**: An NTCIP term referring to an element of data in an NTCIP-compatible device that can be manipulated to control or monitor the device.
- **Page:** An NTCIP term referring to the data displayed on the LED panel matrix at a given moment in time. It is also referred to as a frame.
- **Pitch**: The center to center distance between two adjacent pixels; measured horizontally or vertically.
- **Pixel:** The smallest changeable (programmable) visual element of an X by Y character pixel matrix of an LED panel.
- **Portable Maintenance/ Diagnostic Computer:** A laptop or portable computer running maintenance and diagnostic software. It can communicate with a sign controller unit, control activation of the sign, and perform diagnostics on the sign and controller.
- **Scenario:** A preset plan that assigns specific displays or actions to a specific DMS or set of signs and /or devices – also known as response strategy.
- **Schedule:** A set of data that determines the time and date when a DMS controller will play a stored message on the LED panel.
- **Set:** A DMS location consisting of one DMS cabinet and one or more DMS.
- **Sign Controller Unit (SCU):** A device used to control and monitor the operation of a DMS. It can have a variety of control interfaces such as a local control panel, a local portable maintenance computer, or a central computer. The equipment within the DMS controller cabinet is not specified by this term. Also known as DMS Controller.
- **Standard Specification:** Standard Specifications for Road and Bridge Construction, State of Nevada Department of Transportation, 2014 or latest edition.
- **Travel Time Sign:** The static sign panel to which LED panels mount. Static panels are not provided by the LED panel manufacturer.
- **Stroke:** Refers to the vertical and horizontal width of the lines and curves of a display font. “Single stroke” denotes character segments that are 1 pixel wide. “Double stroke” denotes character segments that are 2 pixels wide.
- **Beacon:** 12 inch yellow LED beacon mounted on DMS.

1.2 ACRONYM GLOSSARY

- **AASHTO:** American Association of State Highway and Transportation Officials
- **ANSI:** American National Standards Institute
- **ASTM:** American Society for Testing and Materials
- **AW:** Amber walk-in
- **AWS:** American Welding Society
- **CAN:** Controller Area Network
- **CMS:** Changeable Message Sign
- **CW:** Color walk-in

- **CSS:** Central System Software
- **DMS:** Dynamic Message Sign
- **FHWA**: Federal Highway Administration, of the U.S. Department of Transportation
- **FSORS:** An NTCIP term meaning "Full, Standardized Object Range Support." See the NTCIP standards for additional information.
- **GFI:** Ground fault interrupter
- **IC:** Integrated Circuit
- **ISO:** International Organization of Standardization ISO 9001: "Quality System Model for quality assurance in design/ development, production, installation and servicing".
- **ITS:** Intelligent Transportation System
- **LCD:** Liquid Crystal Display
- **LED:** Light Emitting Diode
- **LRFD:** Load and Resistance Factor Design
- **MIB:** Management Information Base part of NTCIP protocol
- **MUTCD**: Manual on Uniform Traffic Control Devices
- **NDOT:** Nevada Department of Transportation
- **NEC:** National Electric Code
- **NEMA:** National Electrical Manufacturers Association
- **NCHRP:** National Cooperative Highway Research Program
- **NTCIP:** National Transportation Communications for ITS Protocol
- **OSHA:** Occupational Safety and Health Administration
- **PCB:** Printed Circuit Board
- **RAM:** Random-Access Memory
- **SCU:** Sign Controller Unit
- **SNMP:** Simple Network Management Protocol
- **USB:** Universal Serial Bus
- **VMS:** Variable Message Signs
- **WYSIWYG:** What You See is What You Get. After a pixel diagnostic test routine is run, what you see on the control computer monitor is a scaled representation of the functional status of each pixel in the LED panel matrix.

2. MATERIALS

2.1 GENERAL

All DMS devices shall adhere to the mandatory conformance requirements as specified in NEMA Standards Publication TS 4-2016, Hardware Standards for Dynamic Message Signs (DMS), with NTCIP Requirements; and shall be in conformance with the requirements of this 2018 NDOT Dynamic Message Sign Specification. If a discrepancy exists between the requirements of this specification and the NEMA TS 4-2016 standard then the more stringent requirement shall be adhered to, unless directed otherwise in writing by NDOT.

The DMS assembly shall include the DMS, SCU, SCU cabinet, DMS housing, housing support structure, and DMS mounting brackets and hardware for connecting to the DMS overhead sign structure shown in the NDOT Standard Plans for Road and Bridge Construction structural details, and all other components installed on and within the sign housing and SCU cabinet to create a complete and functional system. (as required). The assembly shall also include associated equipment such as a pole mounted or roadside SCU cabinet, ambient light photo-electric sensor system and all control and power cabling between the DMS and SCU.

Logos of DMS vendors are not be placed on outside of the sign.

DMS construction shall utilize the latest available techniques and the minimum number of different parts, subassemblies, circuits, cards and modules to maximize standardization and common characteristics. Test points shall be provided for checking essential voltages.

For walk-in signs, all component parts of the sign except components housed in the sign SCU shall be accessible for inspection and maintenance within the sign.

The DMS shall be designed for a minimum service life of 20 years.

At the discretion of the Department, poor workmanship that does not present a clean and neat appearance shall be cause for rejection of the DMS assembly.

All cables shall be secured neatly within the sign housing.

The performance including visibility and legibility of the display shall not be impaired due to continuous vibration caused by wind, traffic, or other factors.

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

2.1.1 Quality Assurance

The facility and company that manufacturers the DMS shall be ISO 9001 certified for a minimum of two years prior to the submittal date for this proposal or shall demonstrate compliance with a quality assurance model that is similar to ISO 9001. The company name, scope and address of the facility shall be all listed on the ISO 9001 certificate and provided with the submittal documents. The name, phone number and address of both the authorized ISO 9001 registrar that certified the company and the authorized ISO 9001 accreditation body shall also be provided with submittal documents. Failure to fully

comply with these requirements and provide all the requested information will be cause for rejection. Previous certifications are not adequate and do not meet this requirement.

2.1.2 Spare Parts and Service

The DMS Vendor shall provide a list and cost estimate of recommended spare parts for each sign type.

All spare parts shall be identical to the parts provided within each type of DMS assembly provided by the Vendor. Each item shall be boxed and labeled with a description of the item, date of manufacture, part number, and manufacturer/vendor name. Additionally, a description of the item's function, removal and installation procedures shall be included with each item.

The manufacturer shall provide customer service that provides technical support and services for the DMS system. The manufacturer shall offer technical support and service, bench level repair services for failed components, and stocking of parts for replacement for the 20-year life span of the sign. The manufacturer shall submit a description for preventative maintenance to the system hardware that should be performed and the schedule for these activities, customer service procedures, and details of how parts and service will be provided for all equipment submitted under this specification.

2.1.3 Warranty

The DMS Assembly and all associated components defined herein shall have a manufacturer's warranty written to guarantee from the manufacturer that the DMS (including the sign, mounting brackets, its internal components, controller and all other items included within this specification) and equipment will be fully functional and remain free of defects in material and workmanship for a minimum of three years from the date of final acceptance. If the manufacturer's standard warranty for the components are for a longer period, that warranty will apply.

In the defined warranty period, the manufacturer shall repair with new materials or replace at no charge, any device, product or other material containing a warranty defect. Warranty repairs and replacements shall not exceed two weeks from date of return to the distributor or manufacturer.

2.2 ENVIRONMENTAL REQUIREMENTS

The SCU, cabinet, sign face, sign housing, and all major units of the DMS equipment shall conform to NEMA TS 4-2016, Section 2 - Environmental Requirements for electrical, transients, temperature and humidity, vibration, shock, and time and timing, unless specified otherwise herein. The DMS manufacturer shall demonstrate conformance with these environmental requirements by certifying that the DMS equipment successfully performed its specified functions under the DMS equipment test conditions set forth in NEMA TS 4-2016, Section 2.2 - DMS Equipment Tests and the DMS manufacturer shall provide the associated testing documentation (equipment type, test procedures, results, and legal names of the companies performing the tests) to the department upon request and within 10 business days of the request.

2.2.1 Temperature and Humidity

All DMS components shall be capable of operating without any decrease in performance over an operating temperature range of -29 °F to +165 °F (-34 °C to + 74 °C) with a relative humidity of up to 95 percent non-condensing, unless otherwise noted in this specification. The storage temperature range shall be from -40 °F to +185 °F (-40°C to +85°C). This shall include, but not be limited to, controllers, LEDs,

power supplies, circuit boards, etc. Refer to NEMA TS 4-2016, Section 2.1.5 – Temperature and Humidity for other temperature and humidity requirements.

2.2.2 Electrical

Refer to section 2.10 - Power Requirements, of this specification, for primary supply voltage requirements. Refer to NEMA TS 4-2016, Section 2.1.3 – Electrical for other electrical requirements.

2.3 DMS MECHANICAL CONSTRUCTION

This section addresses the major types of DMS housings in terms of their mechanical construction and application. All DMS housings shall provide protection for and access to items such as display devices, and other internal DMS components.

2.3.1 General

The design life of DMS, operating for 24 hours a day and operating in the extreme climates of Nevada, shall be 20 years or longer. Components with less than a twenty-year design life shall be identified by the manufacturer as a serviceable component.

DMS housings shall be constructed to present a clean, neat appearance to the traveling public. The DMS equipment shall be modular in design so that it is not necessary for a technician to remove or replace discrete components in the field in order to analyze and/or correct a failure.

2.3.1.1 Weather-Tight Enclosure

The DMS housing, including its face panels, shall be designed to conform to the requirements of NEMA Type 3R, as described in the latest edition of NEMA 250 and provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (hose directed water) per NEMA Type 6. All connections shall be watertight. Refer to NEMA TS 4-2016, Section 3.1.3 – Weather-Tight Enclosure for other requirements.

2.3.1.2 Temperature Control

2.3.1.2.1 Ventilation Considerations for Housings that May be Entered

All DMS walk-in assemblies shall be equipped with a forced air fan ventilation system to provide outside air to the interior of any walk-in housing at the minimum rate of 150 cubic feet per minute and the ventilation system shall be of sufficient size as to never permit temperatures inside the DMS housing to exceed 135°F in direct sun with all equipment in operation.

All intake and exhaust vents shall meet NEMA 3R requirements, as described in the latest edition of NEMA 250, with or without power to the air venting arrangement. All vents shall be furnished with a screen to prevent insects from entering the DMS housing.

The manufacturer shall ensure proper precautions are taken for continued operation of the sign within the temperature range specified in NEMA TS 4-2016, Section 2.1.5 – Temperature and Humidity. The SCU shall transmit the error message back to the central control location if the forced air system fails.

For the walk-in DMS housings, a manually activated ventilation system and additional temperature sensor shall be installed to accurately measure the ambient temperature outside the sign housing and ensure the inside temperature of the sign housing is within 10°F of the outside ambient temperature. There shall be no separate air conditioning units permitted. The manually controlled ventilation system shall be controlled from either the central computer and the SCU and/or a portable maintenance / diagnostic

computer, and manually from a timer-switch located within reach of the DMS entrance door inside the sign housing. The timer switch shall have an adjustable minimum time range of one hour and shall turn off the fans when time expires.

For the walk-in DMS housings there shall be a minimum of one or two temperature displays designed for use in hot environments. If one temperature display is used then it should be located at the midpoint of the DMS housing, but readable by maintenance personnel from the housing entrance. If two temperature displays are used then one of the displays shall be at the entry of the housing and the other at the opposite end of the housing, visible from the housing entrance. Each display shall be accurate to within three degrees Fahrenheit and clearly visible and readable by a person with 20/20 vision (natural or corrected) at the entrance of the housing. Liquid crystal displays (LCD's) shall not be allowed. These current temperature readings from inside the housing shall be transmitted to the central control system via the SCU.

2.3.1.2.2 Temperature Considerations for Continued DMS Operation

The manufacturer shall ensure proper precautions are taken for continued operation of the sign within the temperature range specified in NEMA TS 4-2016, Section 2.1.5 – Temperature and Humidity.

If fans are required for continued DMS operation, the fans shall be either thermostatically controlled or controlled by the DMS controller.

If temperature monitoring is required for continued DMS operation, the sensors shall be located at those points that are most critical to the operation.

2.3.1.3 DMS Face

The DMS face is the portion of the sign that is exposed to the environment through or upon which a message is displayed. The DMS manufacturer shall ensure the DMS sign face will remain free from fogging and condensation throughout the life of the sign. NEMA TS 4-2016, Section 3.1.3 – DMS Face shall be considered as "mandatory" conformance requirements of this specification.

2.3.1.4 Galvanic Protection

NEMA TS 4-2016, Section 3.1.4 – Galvanic Protection shall be considered as "mandatory" conformance requirements of this specification.

2.3.1.5 Light Leaks

The DMS housing shall be constructed in such a manner to prohibit stray light from reducing legibility, per NEMA TS 4-2016, Section 3.1.5 – Light Leaks.

2.3.1.6 Contrast Border

The contrast border is the blank space surrounding the message used on a DMS. Except for Type 3 signs used in modular sign applications, all sign shall be provided with a contrast border installed on the perimeter of the DMS to increase the amount of blank space surrounding the message.

When Type 3 signs used in a modular sign application, they shall be provided with a contrast border installed on the edges of the signs that a located along the perimeter of the overall viewable display (i.e., modular sign edges that are adjacent to another modular sign to create a larger viewable display shall not have a contrast boarder between the modular signs). The contrast border shall be a matte black color and closely approximate the off-state color of the display.

If separate panels are attached to the DMS to increase the contrast border of the DMS, the panels shall be securely fastened to the DMS housing and be able to withstand the required design loadings. The attachment of any panels to increase the contrast border to the DMS housing shall be made to block light leaks from behind the DMS that may be seen through the front of the DMS (as viewed from the roadway surface).

2.3.1.7 Flashing Beacons

Each DMS shall have 2, 12-inch LED amber flashing beacons structurally mounted to the top of the sign housing with high contrast back plates. Flashing beacons shall be self-dimming and capable of being controlled by the CSS through the DMS controller. Flashers shall have the capability to flash in wig-wag configuration, be on, be off, or be in steady flashing state.

2.3.1.8 Photocells

Three (3) photocells shall be installed on each sign housing and shall be connected to the SCU to regulate brightness of the display. These devices shall permit automatic light intensity measurement of light conditions at each sign location.

These photocells shall be mounted in an easily accessible area to measure front, rear and ambient light conditions. The mounting devices for the photoelectric cells shall allow full adjustment of the cell orientation, or the photocells shall be installed so that obstruction of light by other parts of the DMS or housing mounting arrangements shall be prevented. Provision shall be made to prevent perceivable changes in the brightness of the sign due to stray headlights shining upon the photo sensors at night.

These photocells shall be connected to the SCU in a manner that allows the SCU to detect if one or more photocells fail. See section 2.9.1.4. - Brightness Controls of this specification for additional information.

2.3.2 Structural Integrity

The DMS housing shall comply with NEMA TS 4-2016, Section 3.2.2 – Structural Integrity and as modified herein.

The DMS housing, the construction of the housing, the housing's attachment to its support structure, and the structure that supports the DMS housing should all be considered as one integral structural system. A Professional Engineer shall check all structural details of this system, including the NDOT Standard Plans for Road and Bridge Construction structural details for the existing or proposed new structure and foundations that supports the DMS housing, and shall seal the structural design of the DMS housing and the housing's attachment to its support structure (also known as mounting brackets and hardware) to assure as a minimum that:

1. DMS, DMS housing, housing support structure, and DMS mounting brackets and hardware for connecting to the DMS overhead sign structure shall not exceed the loading requirements identified in the NDOT standard details for the structure and foundations. NDOT standard structural details are provided in Appendix A for reference.
2. The DMS, DMS housing, housing support structure, and DMS mounting brackets and hardware for connecting to the DMS overhead sign structure shall comply with criteria found in AASHTO 2015 LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals and is designed to withstand environmental loadings as specified in AASHTO 2015 LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals TS-6 Sections 3.8.5 and 3.8.6.

3. Evaluate and choose methods and develop details for mounting brackets and for attaching the DMS housing to existing or proposed sign support structures based on the NDOT Standard Plans for Road and Bridge Construction structural details.
4. Determine appropriate methods and hardware for DMS erection.
5. The DMS housing has been fabricated in accordance with ANSI/AWS D1.2 Structural welding code – Aluminum, if welding is used.
6. DMS mounting brackets and hardware for connecting to the galvanized steel DMS structure shown in the NDOT Standard Plans for Road and Bridge Construction structural details shall be composed of galvanized steel materials conforming to Section 506 of the Specifications.
    - If galvanized steel materials are not used, for the DMS housing clearly identify what materials are being used for the housing and the associated materials that will be provided as a measure of protect against galvanic corrosion, in conformance with the AASHTO Standard, due to contact of dissimilar materials with the galvanized steel mounting brackets and hardware being used for connecting to the galvanize steel structure identified in the NDOT Standard Plans for Road and Bridge Construction structural details.
7. DMS housing shall be provided with an additional fixed mounting bracket or an adjustable mounting bracket to support mounting the DMS housing at a fixed or adjustable 3 degree downwards angle, so the DMS Face is slightly pointed downwards towards oncoming traffic.

2.3.3 Aluminum Housings

DMS housings constructed with aluminum shall comply with NEMA TS 4-2016, Section 3.2.3 – Aluminum Housings and Aluminum alloy shall be 5052-H34, 5052-H32, 3003-H14, 6061-T6 or better.

Aluminum alloy sheets shall not be less than 1/8 inch (3mm) thick, unless otherwise specified in this document.

If welding is used, all welding shall be in accordance with the American Welding Society (AWS) Standards, ANSI/AWS D1.2 with continuously welded seams. The DMS manufacturer's welders and welding procedures shall be certified by an ANSI/AWS Certified Welding Inspector to the 2014 ANSI/AWS D1.2 Structural Welding Code for Aluminum. Proof of certification of all the DMS manufacturer's welders and applicable welding procedures shall be supplied with the submittals. The name, phone number and address of the ANSI/AWS Certified Welding Inspector that certified the DMS manufacturer's welders and procedures shall also be provided with the submittals.

Chemical bonding may be used as an alternate method of attaching the aluminum sheeting to the housing extrusion. Chemical bonding is defined as the use of a two-part structural adhesive to permanently structurally bond the housing materials. The adhesive will be applied in a continuous bead on all housing extrusion surfaces that contact the aluminum sheet. The adhesive will provide the necessary structural bond between the aluminum sheet and the housing extrusion as required by the contract specifications and other pertinent standards and codes. The adhesive will ensure a watertight seal is obtained around the entire perimeter and where any aluminum sheets are spliced.

To ensure that appropriate procedures are followed to bond the aluminum sheet and housing extrusion, the structural adhesive manufacturer will certify the DMS manufacturer. The DMS manufacturer is responsible for performing all necessary testing of the adhesive to meet all requirements of the contract specifications.

Each DMS housing shall have an anodic coating conforming to MIL-A-8625C (Anodic Coatings for Aluminum and Aluminum Alloys) or be painted light gray meeting or exceeding Section 623.02.07 - Painting of the NDOT Standard Specifications for Road and Bridge Construction.

All materials shall be new, corrosion resistant and in strict accordance with these specifications and any exhibits that accompany them.

The DMS manufacturer shall ensure the sign is designed to prevent condensation of moisture and/or the accumulation of frost in front of the pixels to maintain legibility of the display.

2.3.4 Housings Made of Structural Steel and Other Materials

Stainless steel sheets shall comply with the ASTM Designation: A666 for Type 304, Grades A or B, or 5052-H32 stainless steel sheets and shall not be less than 1/8 inch (3mm) thick, unless otherwise specified in this document.

If cold roll steel is used, all cold roll steel shall be plated. All plating shall be either cadmium plating meeting the requirements of Federal Specification QQ-P-416C, Type 2 Class 1 or zinc plating meeting the requirements of Federal Specification QQ-Z-325B, Type 2 Class 1. Cold rolled steel sheet, rod, bar, and extruded shall be Type 1018/1020.

If welding is used, all welding shall be by in accordance with the American Welding Society (AWS) Standards, ANSI/AWS D1.1 with continuously welded seams. The DMS manufacturer's welders and welding procedures shall be certified by an ANSI/AWS Certified Welding Inspector to the 2014 ANSI/AWS D1.1 Structural Welding Code for Steel. Proof of certification of all the DMS manufacturer's welders and applicable welding procedures shall be supplied with the submittals. The name, phone number and address of the ANSI/AWS Certified Welding Inspector that certified the DMS manufacturer's welders and procedures shall also be provided with the submittals.

Each DMS housing shall have a protective coating that shall be designed, tested and certified for durability according to ISO 11997 (Corrosion), and according to ISO 4892 (accelerated weathering) or be painted light gray meeting or exceeding Section 623.02.07 - Painting of the NDOT Standard Specifications for Road and Bridge Construction.

All materials shall be new, corrosion resistant and in strict accordance with these specifications and any exhibits that accompany them.

The DMS manufacturer shall ensure the sign is designed to prevent condensation of moisture and/or the accumulation of frost in front of the pixels to maintain legibility of the display.

2.3.5 Front and Rear Access DMS (Non-Walk-In)

The non walk-in access DMS housings shall comply with NEMA TS 4-2016, Section 3.2.5 – Front and Rear Access and as modified herein.

Type 1 and Type 2 non walk-in DMS shall adhere to the maximum requirements for the following parameters:

	Type 1	Type 2
Parameter	**Maximum**	**Maximum**
Outside length of sign housing	28.25 feet	12.16 feet
Outside height of sign housing	8.0 feet	6.16 feet
Outside depth of sign housing	1.5 feet	1.5 feet
Top/Bottom/Left/Right contrast border width	10 inches	10 Inches
Sign housing weight with all contents	4000 lbs	900 lbs

Table 3: Non Walk-in Housing Dimension Requirements

The above dimensions do not include lifting, mounting provisions, beacons or photocells. All primary components within the DMS housing shall be easily removable without the use of tools of any kind.

2.3.5.1 Front Access Panels

Front access panels on non-walk-in DMS shall open without the removal of any external parts to allow maintenance personnel to access internal components. Access panels along with anything else involving loose sign components during maintenance shall be tethered to the sign assembly.

2.3.5.2 Rear Access Panels

The opening of a rear access door shall be designed to allow immediate access to the internal electronic components and light sources without having to remove any item in the DMS. Access panels along with anything else involving loose sign components during maintenance shall be tethered to the sign assembly.

2.3.6 Walk-In Access DMS

Walk-in DMS housings shall comply with NEMA TS 4-2016, Section 3.2.8 – Walk-In Access DMS and as modified herein.

Type 1-AW and Type 1-CW walk-in access DMS shall adhere to meet the minimum and maximum requirements for the following parameters:

Parameter	Minimum	Maximum
Outside length of sign housing	-	28.25 feet
Outside height of sign housing	-	8.0 feet
Outside depth of sign housing	-	48.0 inches
Top/Bottom/Left/Right approximate border width	-	1.0 foot
Clear internal height along walkway at obstructions (Type 1-AW/CW)	6.0 feet	-
Clear internal height along walkway without obstructions (Type 1-AW/CW)	6.5 feet	-
Clear internal walkway width at obstructions (Type 1-AW/CW)	(2.0 feet)	-

Clear internal walkway width without obstructions (Type 1-AW/CW)	2.5 feet	-
Clear internal landing area adjacent to door (Type 1-AW/CW)	2.5 feet x 2.5 feet	-
Sign housing weight with all contents	-	4,000 lbs

Table 2: Walk-in Housing Dimension Requirements

For the Walk-in Access DMS outside dimensions do not include lifting, mounting provisions, beacons or photocells.

Each walk-in sign housing shall be designed for attachment to the support structure identified by the Department in Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 6th Edition, with 2015 Interim Revisions. Appropriate support structure shop drawings or design plans for each DMS location will be furnished by the Department. Structure designs may vary between locations, and may require different mounting strategies.

The DMS housing shall be designed and arranged such that all maintenance can be performed from inside the housing, except for cleaning of the front panel and maintenance of the photocells. All primary components within the DMS housing shall be easily removable with use of simple hand tools (such as screwdrivers or a crescent wrench). All necessary tools shall be tethered so as not to fall to the ground during maintenance activities.

2.3.6.1 Access Door(s)

The entrance door shall withstand a 200 lb vertical load applied anywhere on the door. The door shall have catches to hold the doors open at 90º. The door shall include gaskets in channels or L-brackets with gaskets made of non-absorbent material and shall maintain its resiliency after long-term exposure to the outdoor environment.

The door lock and key system shall match that provided for the SCU cabinet. A door switch and contact closure shall be provided to send a "DMS housing door open" alarm to the SCU.

2.3.6.2 Work Area

NEMA TS 4-2016, Section 3.2.8.2 – Work Area shall be considered as "mandatory" conformance requirements of this specification.

Interior walkway must not be obstructed, and work area shall be clear for maintenance personnel activity.

2.3.6.2.1 Utility Shelf

A fold or pull out flat surface or shelf shall be provided in walk-in DMS housing work area to allow for use of the laptop or placement of documents. The elevated shelf shall be 12" (304 mm) deep by 18" (457 mm) wide, a comfortable distance above the walkway floor for maintenance personnel use and located within 4 feet of a work area convenience outlet.

2.3.6.3 Nighttime Service Lighting

The DMS housing interior shall have nighttime service lighting along the full length of the interior of the DMS housing using LED lighting technology. The interior lighting shall be vibration resistant to provide maintenance personnel with a minimum of 240 watts equivalent of evenly distributed lighting within the sign. The lamps shall be enclosed in heavy-duty protective fixtures. The lights shall be "rapid start" and rated for 0°F (17.8°C). The light circuit shall be controlled by a manual timer switch having an adjustable

ON time. The ON time shall be a minimum of at least 2 hours and maximum of 12 hours. The switch(es) that control(s) lighting shall be located just inside any door and within easy reach from outside the DMS housing.

2.3.6.4 Convenience Outlets, Walk-In Access

120 VAC duplex convenience outlets shall be located on each end of the DMS housing and at 8 feet (2.4 meter) minimum spacing along the sign housing interior. The outlets shall have integral ground fault interrupt (GFI) that is resettable from inside the housing and be protected by a circuit breaker that is not being used for the display electronics. The receptacles shall be NEMA Type 5-15 R and shall have a spring-loaded cover and be positioned so that no electrical hazard shall exist when used by service personnel.

2.4 CONTROLLER TO DMS INTERFACE

2.4.1 Interface with DMS Housing

The DMS, the SCU, and cabling between the DMS and SCU shall be considered as one closed system. The communication protocol and any command sets needed between the SCU and the DMS shall be dictated by the manufacturer. These protocols and command sets shall be independent of any communication protocol and command set used by the SCU to communicate to any device outside of this closed system (i.e., NDOT central system software).

2.4.2 Wiring

The DMS Vendor shall be responsible for furnishing all control and power cables within and between the DMS and the SCU to power, control, and evaluate/monitor the assembly.

All wiring shall be in accordance with NEMA TS 4-2016, Section 8.2.2, except that non-sheathed ribbon cables shall not be allowed between a SCU cabinet and DMS.

Splices shall not be allowed in the wiring run between the DMS and the SCU.

2.4.3 Wire Entrances

NEMA TS 4-2016, Section 4.3 – Wire Entrances shall be considered as “mandatory” conformance requirements of this specification.

2.4.4 Pixel Control Wiring

NEMA TS 4-2016, Section 4.4 – Pixel Control Wiring shall be considered as “mandatory” conformance requirements of this specification, unless modified otherwise herein.

The voltage to the LED drive modules and associated electronics shall not exceed 30 VDC. The power supplies shall be paralleled in a diode or configuration such that one supply may completely fail, and the sign will still be supplied with enough power to run 100% of all pixels at 100% duty cycle at 149°F (65°C). This includes configurations with power supplies located in the SCU cabinet. Failure of any single power supply shall produce no noticeable effect of the message display.

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

The LED pixel LED drive modules shall be powered with auto-ranging regulated switching power supplies that convert the incoming AC to DC at a nominal voltage of 24 volts DC, or less. Power supplies shall be wired in a redundant configuration that uses multiple supplies for the DMS display matrix.

2.4.5 Laptop Communication Cable

A shielded, extended range cable shall be installed in conduit from the SCU cabinet to the sign housing to allow for portable maintenance / diagnostic computer (i.e., a laptop computer or other approved method) operations of the SCU from the sign housing location. At the SCU, the cable shall be terminated with a connector that mates with the portable maintenance / diagnostic computer Ethernet connector of the SCU. In the sign housing the cable shall be terminated with a connector that mates with a laptop Ethernet port. Sufficient slack shall be provided in the sign.

2.5 DISPLAY PROPERTIES

2.5.1 General

The DMS message shall appear to the display within 3 seconds. One hundred percent pixel monitoring shall be remotely available to the central software and portable maintenance / diagnostic computer. Real-time display human factor specifications used by the DMS Vendor for defining the DMS assembly character sets shall be submitted to the Department for approval.

All fonts shall meet the character dimensions of the MUTCD, Section 2L.04 paragraph 08. The sign shall be capable of displaying ASCII/ANSI character codes 32 through 126 (which includes all English upper and lower case letters “A” through “Z”, punctuation characters such as: . , - ” ‘ ! ? : ; and other characters, such as: # & + / () [] < > ^ ~ $ % * @ , digits from 0 to 9, a blank space, and directional arrows) at any location in a message line. If required, the sign shall be able to substitute a special graphics character for any of these characters.

Left, center, right, top and bottom text justification shall be provided.

2.5.1.1 Graphics

The displays shall support graphics in messages. The graphics shall comply with NTCIP 1203 v3 requirements and standard graphics support. Full-color signs shall display the colors prescribed in the MUTCD, Section 1A.12.

2.5.2 Contrast Ratio

All DMS (amber and color, Type 1, 2, and 3 signs) shall comply with NEMA TS 4-2016, Section 5.2 – Contrast Ratio

2.5.3 Cone of Vision Type Classification

All DMS (amber and color, Type 1, 2, and 3 signs) shall provide a 30-degree cone of vision for both horizontal and vertical planes, and this cone of vision shall be type classified for both daytime and nighttime operating conditions, as defined in Section 5.3 – Cone of Vision Type Classification of the NEMA TS 4-2016 and below:

The LED manufacturer shall assure color uniformity and consistency on the LED display within the 30° cone of vision. Inconsistent shifts in color or intensity will be cause for rejection.

2.5.3.1 Daytime

Per NEMA TS 4-2016, Section 5.3.1.1 – Daytime

2.5.3.2 Nighttime

Per NEMA TS 4-2016, Section 5.3.1.2 – Nighttime

2.5.4 Luminance Intensity Requirements

The luminance intensity even during adverse environmental conditions (e.g. low sun height at 5 degrees above horizon) shall meet or exceed the NEMA TS 4-2016 Section 5.4 for intensity and uniformity.

LEDs shall be obtained from a two-bin luminous intensity sort. A bin is defined such that, when all LEDs from a given bin are driven with an identical forward current, the dimmest LED in the bin emits no less than half the luminous intensity of the brightest LED in the bin. Intensity sorting shall be performed by the LED manufacturer.

2.5.5 Chromaticity Classifications and Limits

Chromacity shall be compliant to NEMA TS 4-2016 Section 5.5 by color for LED technology, ensuring differentiation between colors during adverse environmental conditions allowing the best legibility and recognition.

2.5.6 Display Characters

The table below identifies changeable message sign (CMS) requirements as defined by the U.S. Department of Transportation, Federal Highway Administration (FHWA) Manual on Uniform Traffic Control Devices (MUTCD) 2009 Edition, Revision 2 dated May 2012.

Requirement		Amber			Full Color			Varies
		Walk-In	Non Walk-In		Walk-In	Non Walk-In		Non Walk-In
		TYPE 1-AW	TYPE 1-A	TYPE 2-A	TYPE 1-CW	TYPE 1-C	TYPE 2-C	TYPE 3
Pixel Pitch (max. or smaller)		70 mm	70 mm	70 mm	20 mm	20 mm	20 mm	20 mm
MUTCD	Lines of Characters (max.)	3	3	3	3	3	3	Varies
	Characters per Line	18	18	12	18	18	12	Varies
	Character Height (min.) / Roadway Speed Limit	18 in	18 in	12 in	18 in	18 in	12 in	Varies
	Legibility Distance	1,000 ft	1,000 ft	750 ft	1,000 ft	1,000 ft	750 ft	Varies

Table 4: MUTCD Text Requirements Matrix

In addition to the requirements identified in the above table, the MUTCD and this specification also require the following:

- Word messages shall be comprised of all upper-case letters, except for letters within symbols and route shield graphics using the appropriate standard colors on the full color 20 mm, or less, pixel pitch signs
- All DMS shall automatically adjust their brightness under varying light conditions to maintain legibility

2.5.6.1 MUTCD Fonts - Character Ratios (Width/Stroke/Spacing)

MUTCD-type fonts are required, and the character ratios used to calculate character width, character stroke, character spacing, or interline spacing is based on the character's height. These ratios shall comply with NEMA TS 4-2016, Section 5.6.2.3.3 – MUTCD Fonts - Character Ratios (Width/Stroke/Spacing) and as summarized in NEMA TS 4-2016, Table 5-15 MUTCD Font Ratios- Width/Stroke/Spacing.

2.5.7 Display Change Time

The display shall be changed from one page of text to another page of text, per NEMA TS 4-2016, Section 5.7 – Display Change Time.

2.5.8 Moving arrows

The display shall be capable of displaying moving arrows, per NEMA TS 4-2016, Section 5.8 – Moving Arrows.

2.5.9 Test Methods

The display test methods shall be per NEMA TS 4-2016, Section 5.9 – Test Methods.

2.6 OPTICAL COMPONENTS

The LED light system shall comply with NEMA TS 4-2016, Section 6.2 – LED Light System and as modified herein.

2.6.1 LED Drive Modules

Modules shall be made up of individual LED pixels. Each module shall also include the LED display circuit board(s). The space between pixels shall be the same horizontally and vertically with columns perpendicular to rows. The horizontal spacing between two LED drive modules shall be such that the horizontal pitch between all pixels is equal. The vertical spacing between two LED drive modules shall be such that the vertical pitch between all pixels is equal. If a proportional spacing technique is offered, variable width characters and spacing considerations are subject to approval by the Department. The modules shall be spaced in a manner in which will appear continuous and uninterrupted by gaps.

Electronics necessary to control pixel data and read pixel status shall be provided. All LED modules and circuit boards shall be fully interchangeable and easily removed from inside the DMS housing for Walk-in housings, or from the front side of the DMS for non-Walk-in housings. The modules shall not require any address switches or adjustments when interchanged or placed in service.

Each LED drive module printed circuit board (PCB) shall ensure:

1. LEDs are held in their intended position

2. LEDs are prevented from being crushed or bent during handling
3. LEDs are protected from damage when the LED drive module is laid on the front surface
4. LED drive modules can be easily removed from the DMS without any tools
5. No stress is put on the LEDs due to differentials of expansion and contraction between the device and the LEDs over the specified temperature range defined in this document
6. LEDs do not become loose or fall off during handling or in the event of vibration
7. Adequate airflow over the leads of the LED drive modules
8. LEDs are securely held while allowing a gap between the device and a minimum of 95% of the body of each LED for airflow
9. The light output of the LEDs at the required viewing angle is not blocked.

The LEDs shall be protected from the outside environmental conditions, including moisture, snow, ice, wind, dust, dirt and UV rays. Epoxy encapsulation of the LEDs shall not be permitted.

2.6.2 LED and Pixel Characteristics

DMS pixels shall be constructed to NEMA TS 4-2016, Section 6 – Optical Components and as modified herein. All LEDs shall have a mean time before failure that is outlined in NEMA TS 4-2016, Section 6.2.2 – LED Selection. LED lenses shall be fabricated from UV light resistant epoxy or polycarbonate.

LED's shall be non-tinted, non-diffused, high-intensity, solid-state lamps. All LEDs shall be from the same manufacturer and LED's of the same color shall have the same part number.

The LED lens diameter shall be 0.2 inches (5 mm), sometimes referred to as a T 1-3/4 style LED package.

LED's shall be rated for 100,000 hours under 100% intensity.

The LEDs in each pixel shall be clustered to maximize long range visibility. All pixels shall have equal on-axis intensity. The method used to provide the equal color and intensity, as stated above, shall be included in the LED and pixel documentation submittals and approved by the Department.

2.6.2.1 Brightness and Color of Each Pixel

The brightness and color of each pixel and the characters or graphics shall be legible under all light conditions at a distance of at least 1,000 feet for Type 1 and at least 750 feet for Type 2 to an up-close distance, for both signs.

Brightness of individual modules shall have the capability to be calibrated or adjusted to match other modules in the sign over the life span of the sign if a module is replaced. Calibration shall be done from SCU or from a device that allow maintenance personnel to see the entire sign. See section 2.9.1.4. - Brightness Controls of this specification for additional information.

For full color matrix signs:

- Red LEDs shall emit red light that has a peak wavelength of 618-630 nm and utilize AlInGaP semiconductor technology.
- Green LEDs shall emit green light that has a peak wavelength of 519-539 nm using InGaN semiconductor technology.
- Blue LEDs shall emit blue light that has a peak wavelength of 460-480nm using InGaN semiconductor technology.

For Amber matrix signs:

- LEDs shall emit amber light that has a peak wavelength of 590 (± 4 nm) and utilize AlInGaP semiconductor technology. Color sorting shall be performed by the LED manufacturer.

2.7 DMS CONTROLLER CABINET (SCU Cabinet)

The DMS controller cabinet is also commonly referred to as the SCU cabinet herein.

2.7.1 General

The DMS controller cabinet shall be provided to house all material needed to interconnect and interface the DMS controller to the DMS, the DMS controller to the communications devices for remote connectivity to the central computer, and connect the DMS, DMS controller, and communications devices to the power feeders, including cables and connectors.

Each DMS assembly shall include a SCU cabinet. The SCU cabinet shall meet all applicable requirements of Section 623.02.24 – Cabinets of the NDOT Standard Specifications for Road and Bridge Construction including anti-graffiti grade paint.

2.7.2 DMS Controller Cabinet Design

Aluminum surfaces (cabinet finish) and outside dimensions of the SCU cabinet shall meet the Model 334 (ground mounted), 336 or 336S (pole mount) cabinet requirements, as specified in the Caltrans Traffic Signal Control Equipment Specifications. Cabinet drawings shall be submitted for approval.

All cabinets shall include the following as a minimum:

- SCU and DMS components required to be in the cabinet
- Fans and thermostat
- Heater
- Duplex outlets
- Uninterruptible Power Supply (UPS) for SCU, cabinet equipment and modem
- Surge protection and lightning protection
- Circuit breaker, RFI suppressor, power input junction terminal
- Two unused 20 Amp, 120 VAC circuit breakers
- Termination panel and terminal blocks
- Harnesses and connectors
- Provisions for grounding by the field contractor
- Installation and mounting harnesses
- One LED light, per door, with door actuation switch
- EIA (Electronic Industries Alliance) equipment rack
- Cabinet electrical diagram and drawing storage
- Cabinet weatherproofing
- Front and rear cabinet door with lock and keys
- Two pull-out shelves. One shelf will be used for test equipment, the other for mounting of communications equipment (the communications equipment shall be placed on the top shelf).

All the equipment and functions required to control the DMS shall be provided by the SCU and SCU cabinet.

2.7.2.1 Doors

The SCU cabinet doors shall be provided with an integral locking system that utilizes a CORBIN No. 2 type lock, wherein a key is required to lock the door, and removable only in the locked position. All locks

shall be keyed alike. Keys shall be interchangeable with keys used by the Department for other cabinets. The DMS Vendor shall supply two keys for each sign cabinet furnished. A door switch and contact closure shall be provided to send a "cabinet door open" alarm to the SCU.

2.7.2.2 Ventilation and Heater

Cabinet ventilation shall consist of two axial fans with a total of 220 cfm rating. Openings shall be covered with removable filters. The filters shall be ECO-AIR Products E355 pleated paper filter, or approved equivalents. The thermostat shall be an adjustable type that has a minimum on/off range of 110°F and off at 84°F (43°C and off at 27°C).

The heater and cabinet fans shall be activated by the thermostat when temperatures drop below a threshold established by either the communication equipment and turned off when temperatures are 5°F (3°C) higher than the minimum threshold. The heater shall be capable of maintaining the minimum temperature threshold indefinitely throughout the cabinet.

2.7.2.3 Lighting

An 18-inch (457 mm) LED light shall be mounted above each door of the cabinet. A door-actuated switch shall be used to turn the light on/off. The lamps shall light the front face of the controller and the rear of the cabinet and shall be positioned such that it does not shine into the technician's eyes.

2.7.2.4 Uninterruptible Power Supply (UPS)

The UPS shall provide full operation of the SCU and communications equipment for a minimum of 10 minutes. The UPS shall be UL listed and meet the following minimum requirements:

- The regulated DC power supplies for the SCU shall be compatible with the DC voltage requirements set forth by the DMS equipment manufacturer
- Operating input voltage range shall be a minimum of 90 to 264 VAC
- Maximum output power rating shall be maintained over a minimum temperature range of –30ºF to +140ºF (-34º C to +60º C)
- Power supply efficiency shall be a minimum of 80%
- Power factor rating shall be a minimum of 0.95
- Power supply input circuit shall be fused
- Automatic output shut down and restart if the power supply overheats or one of the following output faults occurs: over-voltage, short circuit, or over-current
- Ethernet communications port
- Automatic output protection (over current, short circuit, and over voltage)
- Surge protected as per ANSI/IEEE C62.41 categories A and B
- Operating environment of -40°F to 165°F (-40°C to 74°C), 5 – 95% relative humidity, non-condensing

2.7.2.5 Rack

The cabinet shall contain a 19" EIA rack for the front and back of the cabinet. The angles shall comply with EIA RS-310B. The cage shall be retractable or shall be bolted at 4 points both top and bottom to the cabinet via the housing cage supports and associated spacers.

2.7.2.6 Shelves

Shelves shall be rack-mounted with ball-bearing slides capable of supporting 20.0 lbs (89.0 N). A minimum of 3 rack-units of clearance shall be provided above the shelf designated for communication equipment. Full depth shelves shall be provided, depending on cabinet type.

2.7.2.7 Serial Number

Each cabinet shall be supplied with a serial number unique to the manufacturer that shall be engraved on a metallic mylar plate that is permanently attached to the inside, upper right side wall of the cabinet.

2.7.2.8 Surge Protection

Power line surge protection devices (SPDs) shall be installed between both line conductors and equipment ground. All conductors entering and leaving the cabinet shall be protected by SPDs. Data lines between the SCU and the sign housing shall also contain surge protection. Power line surge protection (an example is GPTS 120 TLC 20P, or EDCO 1210 SHA) shall conform to the following requirements:

Requirements	Associated Criteria
Peak surge current occurrences	20 minimum
Peak 8x20 Msec wave shape	20K amps
Clamp voltage at 20K amps	250 maximum
Response	V<250 during all portions of surge
Max. current at 120 VAC, 60Hz	10 amps
Series inductance	200 Microhenries
Temperature	NEMA TS-1
Maximum Dimensions	3.3” x 15.0” x 2.6”

Table 5: Surge Protection Table

The power line surge protector shall be a two-stage device that allows the connection of a radio interference filter in the circuit between the stages. Each cabinet shall be equipped with one or more radio interference filters in the power line surge protector. The filter shall provide attenuation of at least 50 dB over a range of 50 kHz to 20 MHz.

2.7.2.9 Duplex Outlets

A minimum of one duplex outlet for maintenance use shall be provided to include two 120 VAC convenience receptacles with integral ground fault interrupt (GFI) and shall be protected by a circuit breaker. The receptacles shall be Type 5-15 R and shall have a spring-loaded cap and be positioned so that no electrical hazard shall exist when used by service personnel.

2.8 ELECTRONICS AND ELECTRICAL

2.8.1 General

Electronics and electrical components shall be arranged so they are easily accessible, replaceable and identifiable for testing and maintenance. Where potential damage by shock or vibration exists, the component shall be supported mechanically.

All DMS equipment shall be electrically grounded per the NEC and during field installation per requirements in Section 623.02.22 – Bonding and Grounding of the NDOT Standard Specifications for Road and Bridge Construction.

2.8.2 Components

Wiring, Cabling, and Harnesses shall comply with NEMA TS 4-2016, Section 8.2.2.

Circuit Loading, Surge Protection and Disconnects shall comply with NEMA TS 4-2016, Section 8.2.3.

Printed Circuit Boards shall comply with NEMA TS 4-2016, Section 8.2.4.

All DMS equipment shall be electrically grounded per the NEC and during field installation per requirements in Section 623.02.22 – Bonding and Grounding of the NDOT Standard Specifications for Road and Bridge Construction.

All 120/240 VAC wiring shall be located in conduit, electrical raceways or control cabinets and protected by thermo magnetic circuit breakers as required by the National Electric Code (NEC). No 120/240 VAC wiring shall be exposed inside or outside of the sign housing and the sign housing and control cabinet shall not be considered as an electrical raceway.

2.8.3 DMS Controller (SCU)

The DMS controller is also commonly referred to as the Sign Controller Unit or SCU herein.

2.8.3.1 General

The DMS controller shall adhere to the mandatory conformance requirements as specified in NEMA Standards Publication TS 4-2016, Section 8.3 – DMS Controller, Section 8.4 – Controller Functions, and as modified herein.

The DMS controller shall meet all applicable environmental and electronic specifications in NEMA TS 4-2016.

The SCU shall meet the following minimum requirements:

- Control all sign functions
- Store messages, as required per this specification
- Monitor sign display and equipment status
- Communicate with the central computer via a separate port, using the NTCIP MIB in the NTCIP 1203 v3
- Provided with its own power supply for connection to the power supply within the SCU cabinet
- Capable of being located at least 300 feet away from the foundation of the DMS structure. The maximum distance between the SCU and the DMS housing and cable types shall be clearly stated in the submittals.

The SCU shall perform a message display verification process and format a message display status message for transmission to the central computer.

2.8.3.2 Communication Interfaces

The SCU shall have separate interfaces and be able to communicate concurrently with both the central computer and the portable maintenance / diagnostic computer so that maintenance and diagnostic

functions can be performed while communications between the SCU and a central computer is on-going. The SCU shall be equipped with at least two Ethernet interfaces and a plain old telephone service (POTS) modem interface.

2.8.3.3 Communications Protocol

The SCU shall communicate with the central system software using the NEMA (NTCIP)-compliant MIB specified in NTCIP 1203 v3 including the Nevada-MIB (Appendix B) and shall support SNMP v2 to maintain communication capabilities with NDOT CSS. It shall not use proprietary protocols. SCUs shall include:

A) The Vendor shall certify the ability to communicate through standard communications ports, with the central system software via the following infrastructures:
   - Twisted-wire pair (TWP) copper cable
   - Single mode fiber optic cable
   - POTS dial-up lines
   - 4G or 3G cellular service
   - Spread spectrum radio or licensed radio microwave frequencies

   The SCU shall not require software/firmware changes to accommodate communications via any of the above infrastructures. External converters that meet or exceed the Temperature and Humidity requirements of section 2.2.1 of this specification may be provided to accommodate communications via the above-mentioned infrastructures.

B) Well-defined configuration parameters and/or settings for the SCU and any associated central and field modems and/or radios as required for the SCU to communicate via each of these communication infrastructures. Well-defined, fully-documented, repeatable and user-friendly procedures for entering these required configuration parameters and/or settings shall also be included. Procedures and associated documentation shall be subject to the approval of the Department.

   The vendor shall demonstrate that the SCUs meet all communications protocol related requirements during DMS assembly testing.

2.8.3.4 Controller Address

Each SCU shall have a unique address that is compatible with the MIB provided in NTCIP 1203 v3. All messages from central control location sent to the SCU will contain the assigned unique address per the MIB specification. With the exception of broadcast messages, the SCU shall compare the address contained within the message with its unique address and shall respond to the command only if the addresses match. See the MIB in NTCIP 1203 v3 for address formats that shall be used.

2.8.3.5 Message Storage Capacity

The SCU shall be capable of storing in its random access memory (RAM) messages sent to it from the central communication location. The SCU shall be capable of displaying all messages stored in its RAM in response to commands from the central communication location.

Independent of the font color, background color, font type and size used in the messages stored in RAM, the SCU shall be able to store a minimum of twenty two (22) page messages of 108 text characters each in RAM. All internal stored messages shall be stored with justification (i.e. left, center, or right). In addition, the SCU shall be capable of storing a minimum of twenty two (22) page, full matrix/graphics messages in RAM. Each of the messages (text and full matrix) shall be addressable from the central control computer though the communications system. These forty (40) messages shall also be addressable via the front panel controls of the SCU and the portable maintenance / diagnostic computer. In the event of a power failure, upon power recovery, the sign display shall display a pre-defined default message. Initial programming provided with the SCU for this default message shall be a blank message (i.e., no message on the display). The display shall continue to display this default message until a new message is activated via a command from central, via an entry in a locally stored schedule, or via the controls on the SCU front panel. In addition to RAM storage, the SCU shall be capable of storing twenty additional text and twenty additional NTCIP 1203 v3 compliant full matrix/graphics messages with full color support in the controller memory for use on site if communication is out or if power goes off and comes back on. Messages pre-stored in controller memory storage area also shall be addressable via the SCU front panel controls.

The DMS sign controller shall support the storage and use of a minimum of twelve (12) font sets that are editable through the portable maintenance / diagnostic computer and from the central software.

2.8.3.6 Front Panel Switches and Displays

The controller shall be a stand-alone microprocessor-based system, which does not require continuous communication with the DMS control software in order to perform DMS control functions. The front panel user interface shall be graphical LCD with a keypad or touch screen for direct operation and diagnostics. The sign controller's front panel shall include a menu driven architecture, keypad and/or touch screen, and a graphical LCD screen. These devices shall be used to perform the following functions with the sign controller and DMS:

- Monitor the current status of the sign controller, including the status of all sensors and a WYSIWYG representation of the message visible on the display face including the use of graphical messages
- Perform all diagnostics testing of various system components including pixels, power systems, sensors, etc.
- Activate, create, preview, and delete messages stored in memory
- Configure display parameters, including display size and color

The front panel interface shall also include:

- Power switch to turn the controller on and off
- LED power "on" indicator
- Automatically manage "Local/remote" states to place the controller in local mode such that it can be controlled from the front panel interface, instead of via the primary NTCIP communication channel, and return to "Remote" state after user logs out or a period of time expires.
- Indicator that shows when the SCU is operating.

2.8.3.7 Types of Messages

The DMS shall display the following types of messages:

A) Static Message

B) Alternating Messages (two page)

The sign shall display two messages alternately with an intervening blank interval from a user-selectable 0 to 25 seconds in 0.1 second increments. The minimum duration between each message displayed shall be user selectable in 0.5 second increments from 0.5 to 60 seconds.

DMS signs have been known to display a portion of one page of an alternating (two-page) message during the intervening (or off) interval that occurs between the displaying of the two pages. This is commonly referred to as the "ghosting effect". DMSs and SCUs operating together shall not exhibit this "ghosting" effect.

2.8.3.8 SCU Status Detection

The SCU shall detect the status of the following at a minimum:

a. Power supply monitor circuitry shall be included to detect power failure.

b. Under voltage condition.

c. Fan failure, when one or more fans are used.

d. Photocell failure.

e. SCU cabinet door open.

f. DMS housing door open and other exterior access panels open.

g. LED module failure.

h. Pixel status.

i. Over temperature.

j. Nevada heater activation. (See MIB in Appendix B of the NTCIP 1203 v3 for protocol)

k. Nevada heater failure. (See MIB in Appendix B of the NTCIP 1203 v3 for protocol)

l. Nevada fan activation. (See MIB in Appendix B of the NTCIP 1203 v3 for protocol)

When the SCU detects one or more of the device failures it will return the condition to the central control system in accordance with the MIB specification.

2.8.3.9 Message Status Monitoring

The SCU shall transmit a return message to the central control system whenever it receives a valid transmission that includes its uniquely assigned address. The return message shall be in accordance with the MIB specified in NTCIP 1203 v3. The text of any message being actively displayed on the sign shall be included in the return message as part of the sign's status. This message must be what is displayed on the sign, not a return of the last message command the sign received.

2.8.3.10 Controller Start Up

After power is turned on, the SCU shall cause the sign display to be blank until a command to display a message is received from the central control location, the portable maintenance / diagnostic computer, a locally stored schedule (if supported), or from the control switches on the SCU front panel. Controller shall store the last message that was displayed in memory.

2.8.4 DMS SOFTWARE REQUIREMENTS

2.8.4.1 General

The manufacturer DMS control software shall be compatible with the most up-to-date NDOT operating system or other Department approved substitutions and shall include all software necessary to control and monitor DMS assembly equipment.

2.8.4.2 Software

The manufacturer software shall allow the operator to control the DMS for all required functions and features of each DMS furnished. The DMS control software shall allow all functions and features of all signs (including the activation of messages by message number), sign status and display to be monitored and controlled from the manufacturer DMS control software.

In addition, the manufacturer DMS control software shall provide the following minimum functions:

- Maintain a library of DMS sign compliant messages in a central database
- Download and upload messages from the library to the sign
- Command the SCU to display messages stored in its memory by sending to the SCU the number of the message to be displayed. This feature shall not require the message content to be sent from central as part of this command.
- Control flashing beacons
- Set the SCU clock
- Set all user adjustable sign parameters
- Re-create the sign display on the workstation display using the WYSIWYG technique
- Initiate and monitor the results of sign diagnostic functions
- Allow users to set polling frequency on a per sign basis
- Allow users to set polling frequency on a "type of communication" basis
- Log on a user ID basis (with time and date stamp) all commands sent to DMS signs that affect their operation
- Log all DMS sign failure state changes with associated time and date stamp
- Log all DMS operational mode state changes with associated time, and date stamp (and user ID if applicable)
- Log all DMS display state changes with associated time, and date stamp (and user ID if applicable)
- Log all user LOGIN and LOGOUT activity with associated time and date stamp
- A log report showing the contents of the log that can be invoked by the user. Report content, format, means of output and method of activation shall be submitted to the Department for approval.
- Report Global Positioning Satellite coordinates for portable DMSs.

The manufacturer DMS control software shall support the following four levels of access, controlled through user IDs and passwords:

- The first level of access provides full access to all diagnostics, status reports, and message change abilities
- The second level of access provides full access to all diagnostics and status reports, but NOT the ability to change messages
- The third level of access provides the ability only to check status reports of any sign in the system
- The fourth level of access provides the ability to edit and enter new messages in the standard message library

The system shall allow at least two (2) remote dial-in users with proper access privileges to check the status of any connected sign, command any connected sign, and change messages on any connected sign just as if the user were physically in the control center.

The central system software shall poll each sign to verify sign status, at user-selectable intervals (on a per sign basis) ranging from once per minute to once per 24 hours.

The software shall be able to report the current status of all signs in a formatted report and to download or change a message on all selected signs with one command.

Independent of the vendor supplied font and graphic type and size used in the stored messages, the manufacturer DMS control software shall be able to store in the central database a minimum of twenty (20) two-page messages of 108 text characters each for each sign in the system. In addition, the manufacturer DMS control software shall be capable of storing in the central database a minimum of twenty (20) two-page, full matrix/graphics messages for an unlimited number of signs in the system. These forty (40) messages (minimum) shall be accessed through a scroll down windows-type interface (or other Department approved type of user interface) and be mouse-selectable.

The manufacturer and central software display shall include a map of the region being served by the project, and geographically show each sign location. The user shall be able to select each sign through mouse clicks on the sign icon.

2.8.5 Laptop Software

The portable maintenance / diagnostic computer software shall be compatible with the SCU and DMS and shall include all software necessary to control and monitor DMS assembly equipment. All SCU and DMS diagnostic functions shall be able to be operated via laptop software.

Laptop software shall include the following minimum functions:

- Maintain a library of text messages
- Placing messages in memory buffer and verifying content
- Download and upload messages from library to the sign
- Command messages for display
- Set the SCU clock
- Set all user-adjustable sign parameters
- Mimic the sign display operation on the laptop display
- Permit simulation of all DMS commands without actually implementing the displays on the DMS
- Display of all characters and graphics on the sign
- Display of static, alternating, and flashing messages of maximum characters
- Activation of all pixels at selectable intervals
- Failure diagnostics and reporting
- UPS operational requirements

2.9 PERFORMANCE MONITORING

2.9.1 Display Diagnostics and Monitoring

2.9.1.1 LED Pixel Tests and Pixel Status Feedback

A pixel test and pixel read shall be provided to the central computer from the SCU.

I. **Pixel Test:** The central computer, on command will automatically once a day perform a pixel test of the current status of sign. The full operational status of each LED in each pixel shall be tested and then transmitted to the central computer. A list of defective pixel statuses shall be provided with line, column, and row numbers for each defective pixel. The pixel test shall be allowed to disturb the displayed message for less than 0.5 seconds.

II. **Pixel Read:** Performed when message is displayed and during every sign poll from the central computer to identify any errors. The pixel read shall perform a real-time read of the displayed message and shall return the state of each pixel to the central computer through the SCU as it is displayed in real-time to the motorist. The central computer operator shall see what is visibly displayed to the motorist on an individual pixel basis or each LED basis. The state of each pixel in the sign shall be read by the SCU to allow the central computer to show the actual message, also known as WYSIWYG format, including static, flashing and alternating messages. The pixel reading shall have no disturbance of the message in any way. Any flashing, flickering, blinking, dimming or other disturbance of the message during the pixel read shall be cause for rejection of the sign.

2.9.1.2 LED Temperature Monitor

Per NEMA Standards Publication TS 4-2016, Section 9.1.2 – LED Temperature Monitor

2.9.1.3 Brightness Controls

The SCU shall provide the means to change the brightness of the display matrix manually or automatically. Manual control will allow the user to select intensity levels, which will be communicated to the LED drivers in all LED panels.

Brightness shall be manually adjustable from the front panel of the SCU and remotely from the central computer in 1% increments (0-100%). Brightness control shall be able to be returned to automatic from the sign controller front panel, the portable maintenance / diagnostic computer and the central computer. The minimum number of user selectable brightness levels shall be three.

If one or more photocells fail, the sign shall revert to a default brightness level and an error message shall be sent to the SCU and transmitted back to the central computer.

The display shall be the proper brightness in all lighting conditions for optimum legibility. It shall be bright enough to have a good target value, but not to the point where the pixels bloom, especially in low ambient light level conditions.

To ensure brightness uniformity over the face of the sign, all LEDs shall be mounted so that their mechanical axis is normal ± 0.5 degree to the face of the sign. The manufacturer shall propose a method acceptable to the Department to test the LEDs in the drive modules to ensure they meet this criteria.

In response to changing ambient lighting conditions as detected by the photocells, automatic adjustment of the LED brightness shall occur in small enough increments so that the brightness of the sign changes smoothly, with no perceivable brightness change between adjacent levels. Brightness changes shall also

be made remotely in response to commands received from the SCU. Provision shall be made to prevent perceivable changes in the brightness of the sign due to stray headlights shining upon the photo sensors at night.

2.9.2 Controller Diagnostics and Monitoring

Per NEMA Standards Publication TS 4-2016, Section 9.2 – Controller Diagnostics and Monitoring.

2.9.3 Error and Failure Log

Per NEMA Standards Publication TS 4-2016, Section 9.3 – Power Line Failures.

2.9.4 Message Verification

Per NEMA Standards Publication TS 4-2016, Section 9.4 – Message Verification.

2.9.5 Defective Character Module

Per NEMA Standards Publication TS 4-2016, Section 9.5 – Defective Character Module.

2.10 POWER REQUIREMENTS

The DMS assembly shall be powered from a single-phase, 120/240 ±15 VAC, 60±Hz primary power source and contain all power distribution assembly devices necessary for powering the DMS assembly components from this primary power source. The DMS and SCU combined power requirement shall not exceed the maximum wattage, for each sign type, identified by the Vendor in response to this solicitation and on subsequent submittals that are required in the construction phase on each construction project that will be installing the DMS Vendor's equipment. The maximum wattage, for each sign type, shall be clearly identified by the Vendor with 100% of all pixels illuminated, at full intensity, during the pixel test operation of the DMS with ventilation system and heaters running.

The DMS assembly shall also be in conformance with the power wiring diagram and load summary table identified by the Vendor in response to this solicitation and on subsequent submittals. The power wiring diagram shall clearly identify all components that are connected to each of the two 120VAC phases and which loads are connected using 240VAC. The load summary table provided shall show the individual loads of each component, a subtotal of the power load on each 120VAC phase, and the overall power load for the 120/240VAC feeder circuit.

All DMS equipment shall be electrically grounded per the NEC and during field installation per requirements in Section 623.02.22 – Bonding and Grounding of the NDOT Standard Specifications for Road and Bridge Construction.

All 120/240 VAC wiring shall be located in an electrical raceway as defined by the NEC (i.e., conduit or other type of electrical raceway) or control cabinets and protected by thermo magnetic circuit breakers as required by the National Electric Code (NEC). No 120/240 VAC wiring shall be exposed inside or outside of the sign housing and the sign housing and control cabinet shall not be considered as an electrical raceway.

3. CONSTRUCTION

3.1 GENERAL

During the construction and installation of DMS equipment for projects there will be requirements of the selected manufacturer to perform under the Contractor.

3.2 DOCUMENTATION

The DMS vendor shall supply documentation for approval by the department after successful completion of all required testing and prior to approval of each DMS installation. Documentation shall include requirements from Section 623.01.03 of the Standard Specification testing documentation, from Section 2.2 of this document, and software documentation including descriptions of all software functions. The documentation shall include descriptions of how DMS operations are related to remote and local commands, program source code in both printed and machine-readable form, detailed memory maps and detailed communications protocol and documentation.

3.2.1 Submittals

The DMS vendor shall provide the following submittals to the Contractor, for Department approval, for each construction project that will be installing the DMS vendor's equipment:

3.2.1.1 Power Requirements Submittal

The power requirements submittal shall include the following for each DMS assembly that is being proposed for use on the Construction Project:

- The maximum wattage of each DMS assembly, based on100% of all pixels illuminated, at full intensity, during the pixel test operation of the DMS with ventilation system and heaters running.
- A load summary table showing the individual loads of each component, a subtotal of the power load on each 120VAC phase, and the overall power load for the 120/240VAC feeder circuit.
- A power wiring diagram that clearly identify all components that are connected to each of the two 120VAC phases and which loads are connected using 240VAC.

3.3 CONSTRUCTION AND INSTALLATION TESTING

3.3.1 General

All testing shall be conducted Monday through Friday during the daytime hours between 8:00 a.m. and 5:00 p.m. for the time zone where the testing occurs, unless otherwise approved by the Department. A DMS Vendor's representative shall be present throughout all tests with NDOT representatives. The Department will review the test results. If the equipment or system fails any part of a test, at the option of the Department, the entire test may be repeated. Unless otherwise noted, the DMS Vendor shall furnish and maintain all required test software, equipment and services.

Actions by the Department or its representative or approval of any test results by them shall not be deemed as acceptance of the equipment or systems tested until successful completion of all tests.

3.3.1.1 Test Procedures and Test Data Forms

The DMS Vendor shall prepare and submit test procedures and test data forms for the Department's approval at least 30 working days before the scheduled testing as required. Test procedures shall be developed specifically in response to these requirements. Do not submit test procedures developed in response to other procurement documents, specifications or for other customers and projects. The Department will review submitted test procedures. At a minimum, the test procedures and data forms shall include the following:

- A step-by-step outline of the test sequence to be followed, showing a test of every function of the equipment or system to be tested. For each test, clearly identify in the test procedure the specific function or requirement being addressed.
- A description of the expected operation, output and test results
- An estimate of the test duration and a proposed test schedule
- A data form to be used to record all data and quantitative results obtained during the test
- A description of any special equipment, setup, manpower, or conditions required for the test

Except as otherwise noted, test procedure submittals shall be processed by the Department as "Submittal Data".

3.3.1.2 Test Equipment and Software

As part of the testing requirements, except as otherwise noted, the DMS Vendor shall be responsible for furnishing all test facilities, including DMS control software, required to complete the required testing. The DMS Vendor shall provide documentation and user instructions for use of any required test equipment and test software unless otherwise directed by the Department. NDOT representatives will provide Central System Software for tests.

3.3.2 Required Tests

DMS assemblies shall be subject to the following four types of tests, after the associated DMS assembly has been selected for the qualified product list and before final acceptance of each installation:

- Factory Acceptance Test (FAT)
- Stand-alone Test (SALT)
- Subsystem Test (SST)
- System Acceptance Test (SAT)

Approved test data forms shall be completed and submitted to the Department for review and approval after each of the above listed tests. Following the completion of a test, an authorized representative of the Department and the DMS Vendor shall sign all test data forms.

3.3.2.1 Factory Acceptance Test (FAT)

FATs shall be conducted on each unit of equipment of the DMS assembly as it comes off the production line. The FAT shall be an operational test and shall check all required functions defined for the FDT as well as those required to successfully complete the SALT. The DMS Vendor shall not deliver the equipment until approval of the FAT results has been provided by the Department.

If a unit fails to pass its FAT, the unit shall be corrected or replaced, and the test repeated until successful.

3.3.2.2 Stand-Alone Test (SALT)

The DMS vendor shall conduct an approved SALT for each DMS assembly to verify that the installed unit operates as specified. The test shall exercise all non-network functional operations of the equipment installed in accordance with the plans or as directed by the Department.

If a unit fails to pass its SALT, it shall be corrected or replaced, and the test repeated until successful.

The SALT for the DMS assembly shall be performed using both the SCU front display panel and the portable maintenance / diagnostic computer. At a minimum, the test shall verify the following:

- Downloading of messages
- Placing messages in memory buffer and verifying content
- Display of all characters and graphics on the sign
- Display of static, alternating, and flashing messages of maximum characters
- Selection of messages from SCU without the portable maintenance / diagnostic computer
- Resumption of normal operations after power is restored
- Activation of all pixels at selectable intervals
- Failure diagnostics and reporting
- UPS operational requirements

3.3.2.3 Subsystem Test (SST)

SSTs verify that units forming a subsystem continue to operate as specified when they are interconnected to the communication hubs.

Conduct and report approved SSTs for the field equipment and related equipment once it is interconnected to form a complete subsystem. For each DMS, demonstrate that messages can be selected, uploaded and confirmed at the central operator workstation using the NDOT central system software. Conduct SSTs on the DMS Assembly, DMS Communication Protocol, Communications Subsystem, and Electrical Service after said equipment has been properly installed and interconnected.

This testing may be conducted from the communication hubs. As part of this testing, periodically poll all devices that support status polling per the Engineer approved field device communication protocols.

SSTs will not be considered successful until all equipment being tested is operational without failure for 72 consecutive hours.

3.3.2.4 System Acceptance Test (SAT)

The purpose of the SAT is to demonstrate that the total system (hardware, software, and ancillary equipment) operates properly as installed, is free from any identified problems, and exhibits stable, reliable performance over time.

SAT testing shall commence upon completion of the SSTs using the NDOT central system software developed for the SST located at the Traffic Management Center. The SAT consists of a 30 to 120 day period of operations without major failure of equipment. Demonstrate that the total system is complete, functioning properly, and meets all requirements. At least once per week, demonstrate that all system functions tested in the SST are operational.

As part of the SAT, use the DMS to post messages for public use, if directed.

Ensure that all equipment is maintained in operable condition during the SAT. Troubleshoot, diagnose, identify, isolate, and resolve all hardware and firmware problems and inconsistencies. Formulate possible solutions and implement all corrections needed.

Have qualified technical personnel, including any required DMS Vendor staff, on-site to operate the system exercising all functions, as required. Make available on-site, key technical personnel familiar with the design and construction of each major system component within 48 hours of notification of a problem.

If an item fails twice during the initial test period after the failure is corrected the test shall be extended an additional 30 days.

Correct all system documentation errors, omissions, and changes discovered and resulting from the SAT and any other testing. System acceptance will not be granted until complete updated documentation is submitted and approved.

3.4 TRAINING

The manufacturer shall provide training to Department personnel for each new type of DMS equipment that has not previously been installed in the region including sign control, software, and maintenance. The manufacturer shall have qualified instructors and provide the following materials to Department personnel:

- Training course outlines
- Samples of all training aids and manuals
- Description of instructors and their qualifications to the Engineer for approval at least thirty days prior to propose scheduled start of training sessions

All training sessions to be conducted at locations as determined by Department. Training shall consist of hands-on training on an actual sign. Training shall consist of a minimum of 16 hours of training on maintenance and repair of the signs and cabinets, 8 hours of training on software and firmware, and 5 hours of training on sign operation (for the sign operators). The training shall consist of a minimum of 2 hours. The manufacturer shall video record all training sessions and provide recordings to the Department for training new personnel in the future.