
20.0 Project Special Provisions

The following pages provide the modified standard specifications that shall be applicable to the Project.

These Contract Provisions are a revised version of CDOT's *Standard Specifications for Road and Bridge Construction*, and contain requirements generally applicable to the Work to be performed by the Contractor. In certain cases, provisions in Section 100 of the *Standard Specifications for Road and Bridge Construction* have been superseded by other provisions of the Contract Documents. For ease of reference, this document uses the same Section numbers as the *Standard Specifications for Road and Bridge Construction*, and identifies provisions of the Contract Documents that have replaced or modified the standard clauses.

All references to "Engineer" that are incorporated into this Section refer to the Contractor's Engineer, unless the context requires otherwise. Non-capitalized terms, such as "work" that are defined in Book 1, Exhibit A, shall have the meanings defined therein unless the context requires otherwise. References to "approve, approval or approved" shall mean "Approve, Approval or Approved" as defined in Book 1, Exhibit A, when the approval is by CDOT or a division of CDOT. If the interpretation(s) pursuant to this paragraph are not clear, CDOT shall decide, in its sole discretion, how these terms shall be interpreted.

When these specifications describe actions, Materials, means or methods that are required and that are qualified by phrases such as: "as directed by the Engineer", "when directed by the Engineer", "as determined by the Engineer", "with or without permission of the Engineer", "in the opinion of the Engineer", "unless authorized by the Engineer", "satisfactory to the Engineer", "as approved by the Engineer", or "unless another type is specified or is permitted with approval of the engineer", such phrases shall be disregarded. If it is not clear whether a phrase should be disregarded, CDOT will make that decision in its sole discretion.

When these specifications refer to "Department", "Resident Engineer", "Agricultural Engineer", "Bridge, Construction or Maintenance Engineer", "TMC system inspector", "Concrete Engineer", "Project Engineer", "Materials Engineer", "Commissioner", "Structural Metals Engineer", "Department's Lighting Engineer", "Geotechnical Engineer" or any other specific CDOT special engineer, such reference shall mean the CDOT Project Manager.

When these specifications use the term "engineer" relating to the approval of any activities involving the use of explosives, such term shall mean the CDOT Project Manager.

When an approval or authorization of the Engineer or CDOT is required in these specifications for the use of alternative or substituted processes or components, the Engineer shall mean CDOT. If it is not clear whether a phrase involves the use of alternative or substituted processes, CDOT will make that determination in its sole discretion.

If these specifications refer to an approval of any correction or repair that deviates from the Contract requirements, the approval must be by CDOT. If it is not clear whether a specification involves a correction or repair that deviates from the Contract requirements, CDOT will make that determination in its sole discretion.

When these specifications provide that reports, records or other documents shall be submitted to CDOT or to the Engineer, such reports shall be made available to CDOT and do not have to be submitted unless either they are otherwise listed in the deliverables in the Contract Documents, or are required shop drawings, warranties, parts lists, instruction sheets or manufacturer’s drawings or specifications. Such documents shall be submitted to CDOT as required by the specifications.

When these specifications require actions, Materials, means or methods that are “either as indicated in the Plans or as designated by the Engineer,” the Contractor shall disregard the phrase “or as designated by the Engineer.”

When these specifications refer to the “Engineer” ordering work beyond the scope of work in the Contract, “Engineer” shall mean CDOT. Whenever in these specifications the Engineer may order work that results in additional costs to CDOT, the “Engineer” shall mean CDOT.

Any acceptances on behalf of CDOT or the State shall be performed by CDOT.

Any references to other standards, codes, or criteria, or to the latest version of other standards, codes, or criteria in Book 2 of the Contract Documents shall mean the latest version at the Proposal Due Date.

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**REVISION OF SECTIONS 105, 106, AND 203
CONFORMITY TO THE CONTRACT OF EMBANKMENT**

Sections 105, 106 and 203 of the Standard Specifications are hereby revised for this project as follows:

Subsection 105.03 shall include the following:

Conformity to the contract of embankment construction shall be determined in accordance with the following:

(a) *Quality Control Plan.* The Contractor shall be responsible for Quality Control (QC) for all embankment material on this project. The Contractor shall submit a written Quality Control Plan (QCP), including a methods statement, to the Engineer for acceptance. The QCP shall include but not be limited to the following:

- (1) Maximum lift thickness of eight inches in accordance with subsection 203.06 or as directed.
- (2) Compaction equipment capable of obtaining the specified compaction.
- (3) Water trucks with an adequate distribution system that will apply water evenly.
- (4) List of all inspection and materials testing forms and procedures utilized by the Contractor.
- (5) Adherence to Table 106-4 requiring minimum testing frequency.

The Contractor shall submit the QCP at least five working days prior to the start of the work. The Engineer's review of the QCP will not exceed two working days. Work shall not begin until the QCP has been accepted in writing, unless otherwise approved.

(b) *Documentation.* The Contractor shall maintain current records of quality control operation activities, and tests performed. These records shall be in the form shown in the QCP, and shall include as a minimum, the Contractor or subcontractor, the number of personnel working, weather conditions, type of equipment being used, delays and their cause, and deficiencies along with corrective action taken. Such records shall cover both conforming and defective or deficient features. Additional documentation to the Engineer shall include all daily test results, daily inspection reports, daily non-compliance reports, and monthly certification reports. Copies of these records and a statement that work incorporated in the project complies with the Contract shall be submitted to the Engineer prior to payment for the work or upon request. Monthly certification reports shall be stamped with the seal of a Professional Engineer registered in Colorado. Failure to provide the Engineer with the necessary documentation will result in the suspension of payments on embankment until the documentation has been completed and accepted by the Engineer. CDOT Quality Assurance documentation shall not be used as supporting documentation for the Contractor's certification.

CDOT or CDOT's certified representative will be responsible for Quality Assurance (QA) and Independent Assurance Testing (IAT).

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**REVISION OF SECTIONS 105, 106, AND 203
 CONFORMITY TO THE CONTRACT OF EMBANKMENT**

Subsection 106.03 shall include the following:

Testing of embankment construction shall conform to the following:

The supervisor responsible for the direct supervision for the process control sampling and testing shall be identified in the QCP and be qualified according to the requirements of CP-10 (Note: this will require a PE or a NICET Level III certification). The technicians taking samples and performing tests must be qualified according to requirements of CP 10 (Note: this will require WAQTC qualification). The contractor shall have a quality control technician on-site full time during any embankment placement operations.

The project verification sampling and testing procedures shown in the CDOT Field Materials Manual under the frequency guide schedule for minimum materials sampling, testing and inspection shall be used for the elements shown in Table 106-4.

**Table 106-4
 EXCAVATION AND EMBANKMENT TESTING SCHEDULE**

Minimum Testing Frequency Contractor's Process Control	Element	Minimum Testing Frequency CDOT verification Testing
None Required	Soil Survey (Classification)	See CDOT Field Materials Manual for Frequency
1 per soil type	Moisture – Density Curve	1 per soil type
1 per 500 cubic yards or fraction thereof.	In-Place Density	1 per 1,000 cubic yards or fraction thereof.
1 per 300 cubic yards or fraction thereof.	In-Place Density when within 100 ft. of Bridge Approach(s).	1 per 500 cubic yards or fraction thereof.
1 per 5,000 cubic yards or fraction thereof.	1 Point Check	1 per 10,000 cubic yards or fraction thereof.

Qualifications for testing and personnel are contained in Section 203, Chapter 200 of the CDOT Field Materials Manual, CP-10, CP 13, CP 15, and CP 80, and the CDOT Inspectors Checklist.

Subsection 203.02 (a) shall include the following:

Unclassified Excavation shall include removal of unstable or unsuitable material within the roadway as determined and directed by the Engineer.

Subsection 203.02 (c) shall include the following:

Embankment material containing significantly more than optimum moisture that would become stable if dried shall not be considered muck.

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**REVISION OF SECTIONS 105, 106, AND 203
CONFORMITY TO THE CONTRACT OF EMBANKMENT**

Subsection 203.13 (b) shall include the following:

The disposal of unsuitable material and replacement of embankment will not be measured and paid for separately, but shall be included in the work.

The Contractor's Quality Control efforts will not be measured and paid for separately but shall be included in the work.

**REVISION OF SECTION 107
PERFORMANCE OF SAFETY CRITICAL WORK**

Section 107 of the Standard Specifications is hereby revised as follows:

Add subsection 107.061 immediately following subsection 107.06 as follows:

107.061 Performance of Safety Critical Work. The following work elements are considered safety critical work for this project:

- (1) Overhead girder erection
- (2) Overhead structure construction or repair
- (3) Removal of bridge
- (4) Removal of portion of bridge
- (5) Temporary works: falsework, shoring that exceeds 5 feet in height, cofferdams, and temporary bridges
- (6) Work requiring the use of cranes or other heavy lifting equipment to set a girder, to make overhead repairs, or includes special provisions for Removal of Bridge or Removal of Portion of Bridge. Also when construction materials are being lifted that may fall onto active traffic lanes.
- (7) Blasting
- (8) Excavation and embankment adjacent to the roadway, especially if it requires shoring
- (9) Tunneling
- (10) Work operations such as pile driving and jack hammering which may create vibration and cause debris to fall into traffic.
- (11) Rockfall mitigation

The Contractor shall submit, for record purposes only, an initial detailed construction plan that addresses safe construction of each of the safety critical elements. When the specifications already require an erection plan, a bridge removal plan, or a removal of portion of bridge plan, it shall be included as a part of this plan. The detailed construction plan shall be submitted two weeks prior to the safety critical element conference described below. The construction plan shall be stamped "Approved for Construction" and signed by the Contractor. The construction plan will not be approved by the Engineer.

The Construction Plan shall include the following:

- (1) Safety Critical Element for which the plan is being prepared and submitted.
- (2) Contractor or subcontractor responsible for the plan preparation and the work.
- (3) Schedule, procedures, equipment, and sequence of operations, that comply with the working hour limitations
- (4) Temporary works required: falsework, bracing, shoring, etc.
- (5) Additional actions that will be taken to ensure that the work will be performed safely.
- (6) Names and qualifications of workers who will be in responsible charge of the work:
 - A. Years of experience performing similar work
 - B. Training taken in performing similar work
 - C. Certifications earned in performing similar work
- (7) Names and qualifications of workers operating cranes or other lifting equipment
 - A. Years of experience performing similar work

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**REVISION OF SECTION 107
PERFORMANCE OF SAFETY CRITICAL WORK**

- B. Training taken in performing similar work
- C. Certifications earned in performing similar work

The construction plan shall address how the Contractor will handle contingencies such as:

- A. Unplanned events (storms, traffic accidents, etc.)
 - B. Structural elements that don't fit or line up
 - C. Work that cannot be completed in time for the roadway to be reopened to traffic
 - D. Replacement of workers who don't perform the work safely
 - E. Equipment failure
 - F. Other potential difficulties inherent in the type of work being performed
- (8) Name and qualifications of Contractor's person designated to determine and notify the Engineer in writing when it is safe to open a route to traffic after it has been closed for safety critical work.
- (9) Erection plan or bridge removal plan when submitted as required elsewhere by the specifications. Plan requirements that overlap with above requirements may be submitted only once.

A safety critical element conference shall be held two weeks prior to beginning construction on each safety critical element. The Engineer, the Contractor, the safety critical element subcontractors, and the Contractor's Engineer shall attend the conference. Required pre-erection conferences or bridge removal conferences may be included as a part of this conference.

After the safety critical element conference, and prior to beginning work on the safety critical element, the Contractor shall submit a final construction plan to the Engineer for record purposes only. The Contractor's Engineer shall sign and seal temporary works, such as falsework, shoring etc., related to construction plans for the safety critical elements, (3) Removal of Bridge, (4) Removal of Portion of Bridge and (5) Temporary Works. The final construction plan shall be stamped "Approved for Construction" and signed by the Contractor.

The Contractor shall perform safety critical work only when the Engineer is on the project site. The Contractor's Engineer shall be on site to inspect and provide written approval of safety critical work for which he provided signed and sealed construction details. Unless otherwise directed or approved, the Contractor's Engineer need not be on site during the actual performance of safety critical work, but shall be present to conduct inspection for written approval of the safety critical work.

When ordered by the Engineer, the Contractor shall immediately stop safety critical work that is being performed in an unsafe manner or will result in an unsafe situation for the traveling public. Prior to stopping work, the Contractor shall make the situation safe for work stoppage. The Contractor shall submit an acceptable plan to correct the unsafe process before the Engineer will authorize resumption of the work.

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**REVISION OF SECTION 107
PERFORMANCE OF SAFETY CRITICAL WORK**

When ordered by the Engineer, the Contractor shall remove workers from the project that are performing the safety critical work in a manner that creates an unsafe situation for the public in accordance with subsection 108.05.

Should an unplanned event occur or the safety critical operation deviate from the submitted plan, the Contractor shall immediately cease operations on the safety critical element, except for performing any work necessary to ensure worksite safety, and provide proper protection of the work and the traveling public. If the Contractor intends to modify the submitted plan, he shall submit a revised plan to the Engineer prior to resuming operations.

All costs associated with the preparation and implementation of each safety critical element construction plan will not be measured and paid for separately, but shall be included in the work.

Nothing in the section shall be construed to relieve the Contractor from ultimate liability for unsafe or negligent acts or to be a waiver of the Colorado Governmental Immunity Act on behalf of the Department.

**REVISION OF SECTION 202
REMOVAL OF ASPHALT MAT (PLANING)**

Section 202 of the Standard Specifications is hereby revised for this project as follows:

Delete subsection 202.09, and replace it with the following:

202.09 Removal of Asphalt Mat (Planing). Prior to beginning planing operations, the Contractor shall submit a planing plan and a Quality Control Plan (QCP) for approval by the Engineer. The planing plan shall include at a minimum:

- (1) The number, types and sizes of planers to be used.
- (2) The width and location of each planing pass.
- (3) The number and types of brooms to be used and their locations with respect to the planers.
- (4) The proposed method for planing and wedging around existing structures such as manholes, valve boxes, and inlets.
- (5) The longitudinal and transverse typical sections for tie-ins at the end of the day.
- (6) If requested by the Engineer, a plan sheet showing the milling passes.

The QCP shall include as a minimum:

- (1) The schedule for replacing the cutting teeth.
- (2) The daily preventive maintenance schedule and checklist.
- (3) Proposed use of automatic grade controls.
- (4) The surface testing schedule for smoothness.
- (5) The process for filling distressed areas.
- (6) The schedule for testing macrotexture of the milled surface.
- (7) Corrective procedures if the milled surface does not meet the minimum macrotexture specification.
- (8) Corrective procedures if the milled surface does not meet the minimum transverse or longitudinal surface finish when measured with a 10 foot straightedge.

The Contractor shall not start the planing operation until the hot mix asphalt (HMA) mix design has been approved and a Form 43 has been signed by the Engineer.

The existing pavement shall be milled to the cross-slope as shown on the plans, and shall have a surface finish that does not vary longitudinally or transversely more than 3/8 inch from a 10 foot straightedge. A 10 foot straightedge shall be supplied by the Contractor.

All milled surfaces shall be broomed with a pick-up broom, unless otherwise specified, before being opened to traffic. A sufficient number of brooms shall be used immediately after planing to remove all milled material remaining in the roadway.

If the Contractor fails to adequately clean the roadway, work shall cease until the Engineer has approved the Contractor's revised written proposal to adequately clean the roadway.

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REVISION OF SECTION 202
REMOVAL OF ASPHALT MAT (PLANING)

The milled surface shall have a macrotexture equal to or less than 0.170 inches for single-lift overlays and 0.215 inches for multiple-lift overlays as tested in accordance with CP 77. Milled surfaces that do not meet these criteria shall require corrective action in accordance with the QCP. The Contractor shall be responsible for testing the macrotexture of the milled surface at the location directed by the Engineer in accordance with CP 77 at a stratified random frequency of one test per 10,000 square yards or a minimum of once per work day.

At the completion of each day's work, longitudinal vertical edges greater than 1 inch shall be tapered. No transverse vertical edges will be allowed. Longitudinal milled surface tie-ins to existing pavement shall be tapered to not less than a 3:1 slope, transverse milled surface tie-ins to existing pavement shall be tapered to not less than a 50:1 slope. Transverse tapered joints may be tapered with the planing machine, a temporary asphalt ramp, or other methods approved by the Engineer. No longitudinal joint between the milled and existing surfaces shall fall between 1 to 5 feet of any lane line.

If the transverse joint is tapered with a temporary asphalt ramp, the milled surface at the joint shall be constructed as a butt joint the full depth of the lift of asphalt to be placed on the milled surface. The Contractor shall be responsible for maintaining this asphalt ramp until all corresponding HMA is placed. All work associated with this joint will not be paid for separately, but shall be included in the cost of planing.

If the transverse joint is tapered with a planing machine, a butt joint shall be cut into the taper the full depth of the lift of asphalt to be placed on the milled surface prior to commencement of resurfacing. All work associated with this joint will not be paid for separately, but shall be included in the cost of planing.

Other approved transverse joint tapers shall be maintained at the expense of the Contractor, and at a minimum shall incorporate a butt joint the full depth of the lift of asphalt to be placed on the milled surface prior to commencement of resurfacing.

Distressed or irregular areas identified in the planed surface by the Engineer shall be patched.

The roadway shall be left in a safe and usable condition at the end of each work day. The Contractor shall take appropriate measures to ensure that the milled surface does not trap or hold water. All required pavement markings removed by the planing shall be restored before the roadway is opened to traffic.

All milled surfaces to be overlaid with HMA shall be covered with new asphalt within 5 working days. All areas on this project that are not overlaid within the specified working days will be assessed a lane rental fee of \$12,500.00 per occurrence for each day or fraction thereof and any required surface repairs shall be paid for by the Contractor.

All planing shall be completed full width and parallel to the travel lanes before resurfacing commences unless otherwise directed by the Engineer.

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**REVISION OF SECTION 202
REMOVAL OF ASPHALT MAT (PLANING)**

All material generated by the planing operation shall become the property of the Contractor unless otherwise noted in the Contract.

Add subsection 202.091 immediately following subsection 202.09 as follows:

202.091 Equipment

Each planer shall conform to the following:

The planer shall have sufficient power, traction and stability to maintain an accurate depth of cut. The propulsion and guidance system of the planer shall be maintained in such condition that the planer may be operated to straight and true lines.

The planer shall be capable of operating with automatic grade controls (contact or non-contact) on both sides of the machine using a 30 foot averaging system or other approved grade control systems. The use of such controls shall be described in the Contractor's QCP.

The planer shall be capable of picking up the removed material in a single operation. A self loading conveyor shall be an integral part of the planer. Windrows will not be allowed.

Subsection 202.12 shall include the following:

Macrotexture testing, macrotexture corrective actions, planers, brooms and all other work necessary to complete the item will not be measured and paid for separately, but shall be included in the work.

**REVISION OF SECTION 202
RECLAIMED ASPHALT PAVEMENT MILLINGS**

Section 202 of the Standard Specifications is hereby revised for this project as follows:

Subsection 202.09 shall include the following:

CDOT will retain 0% of the Reclaimed Asphalt Pavement (RAP) millings removed from the existing mat on this project. All remaining RAP millings, if any, shall be used in the project as allowed in the Contract or as approved by the Engineer. Otherwise, they shall become the property of the Contractor and shall be disposed at his expense outside the project limits.

If the Contractor desires to retain a quantity of RAP millings that exceeds that allowed by this Contract, the Contractor may request this by submitting a Value Engineering Change Proposal (VECP) in accordance with subsection 104.07.

Subsection 202.12 shall include the following:

Unless otherwise specified in the Contract, the disposal and hauling of the RAP millings to other locations or its use on the project or at other locations will not be measured and paid for separately, but shall be included in the work.

**REVISION OF SECTION 203
EMBANKMENT MATERIAL**

Section 203 of the Standard Specifications is hereby revised for this project as follows:

In subsection 203.03(a), first paragraph, after the second sentence add the following:

Embankment material within the top two feet of design finished subgrade elevation shall have a minimum R-value of at least 60 when tested by the Hveem Stabilometer. All remaining embankment material shall have a minimum R-value of at least 40 when tested by the Hveem Stabilometer. Additionally, all embankment material placed for this project shall be either A-1 or A-2 when classified in accordance with AASHTO M 145.

**REVISION OF SECTION 203
CONCRETE STAINING**

DESCRIPTION

This work consists of staining structures on the project.

MATERIALS

The stain shall be an aqueous solution containing salts of iron and manganese and other trace elements including copper and zinc. Involving an artificially accelerated, multi-step oxidation process. The material shall contain no caustic or alkaline chemicals. The material shall be manufactured as a concentrate that can be diluted with potable water to achieve the desired color. The stain shall consist of a singular color. Colors shall be such that alteration of the color and further color development after initial application can be accomplished.

CONSTRUCTION REQUIREMENTS

Prior to application of stain, test plots shall be set up in an inconspicuous location, as directed by the Engineer, to test several concentrations of stain. Parties involved in the approval of the staining shall be notified 5 days prior to applying the stain to the test area. Test staining will ensure color achieves the specified color in depth and tone. Stain shall be applied to a minimum of (2) 30-foot X 30-foot test locations.

The stain shall be in accordance with the approved color sample. The stain shall be applied in accordance with the printed instructions of the stain material manufacturer. Caution shall be exercised to provide all necessary protection to the body during application as recommended by the manufacturer. A copy of such printed material shall be furnished to the Engineer prior to application of the material.

After application of the test stain, sites shall remain undisturbed and allowed to set color for a period of 7 days. After 7 days a determination shall be made to the concentrations of stain required on the project. Concentrations of stain may need to be adjusted within the ranges approved to adjust to specific on site conditions. Written approval from the Landscape Architect is required.

Prior to applying the stain, all surfaces shall be cleaned by high pressure washing with water. Staining shall be performed once the concrete is complete, has been completely cured and dry, and freed of soil or debris. The solution should be applied directly to a surface of the item being stained.

Concrete staining shall consist of applying a minimum of three (3) separate applications of the specified color to the specified areas. Stain shall be applied prior to the application of any curing compound.

Do not apply stain if winds exceed 15 mph or stronger, with no anticipated precipitation in the forecast for 12 hours. Best results occur if stain is applied when temperatures are 70 degrees Fahrenheit or higher and if temperatures remain with a 10 degree margin for 30 days. If applying in cooler temperatures, allow stain to dry completely before surface becomes moist. Material shall be stored in an air tight container, in a cool dry space.

**REVISION OF SECTION 211
DEWATERING**

Section 211 is hereby added to the Standard Specifications for this project as follows:

DESCRIPTION

211.01 This Work consists of dewatering to facilitate construction activities.

CONSTRUCTION REQUIREMENTS

211.02 Groundwater within the Project limits has contaminants at concentrations greater than that acceptable for direct discharge under standard NPDES permits and other beneficial uses. The Contractor shall manage contaminated groundwater in accordance to the requirements herein. For additional support information the Contractor is referred to Book 3 – Applicable Standards, Data and Reports and Book 5 – Reference Documents.

Removal, sample collection, analytical testing, containerization, transportation, and disposal or treatment of all contaminated groundwater shall be in accordance with Standard Specifications 250, and 107.25 and the Contractor's Dewatering Plan and Materials Management Plan. The Contractor shall manage the Work according to guidelines and criteria from CDPHE and the State Engineer's Office.

The Contractor shall:

1. Minimize the disturbance of contaminated groundwater by avoidance.
2. Limit intrusion of groundwater into excavations.

The Contractor shall obtain the appropriate Colorado Discharge Permit System (CDPS) general permit for management of groundwater from CDPHE Water Quality Control Division. A completed application shall be submitted to CDPHE at least 4 weeks prior to commencement of dewatering operations.

In accordance with permit procedures, the Contractor shall fill out and submit a monthly Discharge Monitoring Report (DMR) to CDPHE for the life of the permit. Copies of monthly submittals shall be provided to the CDOT Project Manager.

The Contractor shall measure the rate of groundwater discharge during the dewatering process using a certified inline flow device capable of measuring flow rates with an accuracy of plus or minus five (5) gallons per minute. The Contractor shall record the rate of discharge daily and shall submit a discharge report to the Engineer weekly.

The Contractor shall submit a Dewatering Plan to the CDOT Project Manager at least 4 weeks prior to the start of dewatering operations. This Plan shall detail the Contractor's method of dewatering for all construction activities. The Dewatering Plan shall be stamped "Approved for Construction" and signed by the Contractor.

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REVISION OF SECTION 211
DEWATERING

The Dewatering Plan shall provide complete details of the Contractor's method for construction dewatering including:

1. Copies of all permits required for dewatering, including treatment of and (or) disposing of contaminated groundwater.
2. If applicable, copies of agreements for disposing of groundwater in storm sewers, sanitary sewers etc.
3. Method and details for minimizing dewatering for all construction activities.
4. Method of measuring groundwater discharge for dewatering activities.
5. Equipment descriptions including size, number, type, capacity, and location of equipment during dewatering operations.
6. Methods of testing groundwater to determine appropriate disposal methods.
7. Detailed methods for disposal of contaminated groundwater.
8. If applicable, name of facility where contaminated groundwater is to be delivered to.

**REVISION OF SECTION 240
PROTECTION OF MIGRATORY BIRDS
BIOLOGICAL WORK PERFORMED BY THE CONTRACTOR'S BIOLOGIST**

Section 240 is hereby added to the Standard Specifications for this project as follows:

DESCRIPTION

240.01 This work consists of protecting migratory birds during construction.

MATERIALS AND CONSTRUCTION REQUIREMENTS

240.02 The Contractor shall schedule clearing and grubbing operations and work on structures to avoid taking (pursue, hunt, take, capture or kill; attempt to take, capture, kill or possess) migratory birds protected by the Migratory Bird Treaty Act (MBTA). The Contractor shall retain a qualified wildlife biologist for this project. The wildlife biologist shall have a minimum of three years experience conducting migratory bird surveys and implementing the requirements of the MBTA. The Contractor shall submit documentation of the biologist's education and experience to the Engineer for acceptance. A biologist with less experience may be used by the Contractor subject to the approval of the Engineer based on review of the biologist's qualifications. The wildlife biologist shall record the location of each protected nest, bird species, the protection method used, and the date installed. A copy of these records shall be submitted to the Engineer.

(a) *Vegetation Removal.* When possible, vegetation shall be cleared prior to the time when active nests are present. Vegetation removal activities shall be timed to avoid the migratory bird breeding season which begins on April 1 and runs to August 31. All areas scheduled for clearing and grubbing between April 1 and August 31 shall first be surveyed within the work limits for active migratory bird nests. The Contractor's wildlife biologist shall also survey for active migratory bird nests within 50 feet outside work limits. Contractor personnel shall enter areas outside CDOT right of way only if a written, signed document granting permission to enter the property has been obtained from the property owner. The Contractor shall document all denials of permission to enter property. The Contractor shall avoid all active migratory bird nests. The Contractor shall avoid the area within 50 feet of the active nests or the area within the distance recommended by the biologist until all nests within that area have become inactive. Inactive nest removal and other necessary measures shall be incorporated into the work as follows:

1. *Tree and Shrub Removal or Trimming.* Tree and shrub removal or trimming shall occur before April 1 or after August 31 if possible. If tree and shrub removal or trimming will occur between April 1 and August 31, a survey for active nests shall be conducted by the wildlife biologist within the seven days immediately prior to the beginning of work in each area of tree and shrub removal or trimming. The survey shall be conducted for each phase of tree and shrub removal or trimming. If an active nest containing eggs or young birds is found, the tree or shrub containing the active nest shall remain undisturbed and protected until the nest becomes inactive. The nest shall be protected by placing fence (plastic) a minimum distance of 50 feet from each nest to be undisturbed. This buffer dimension may be changed if determined appropriate by the wildlife biologist and approved by the Engineer. Work shall not proceed within the fenced buffer area until the young have fledged or the nests have become inactive.

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**REVISION OF SECTION 240
PROTECTION OF MIGRATORY BIRDS
BIOLOGICAL WORK PERFORMED BY THE CONTRACTOR'S BIOLOGIST**

If the fence is knocked down or destroyed by the Contractor, the Engineer will suspend the work, wholly or in part, until the fence is satisfactorily repaired at the Contractor's expense. Time lost due to such suspension will not be considered a basis for adjustment of time charges, but will be charged as contract time.

2. *Grasses and Other Vegetation Management.* Due to the potential for encountering ground nesting birds' habitat, if work occurs between April 1 and August 31, the area shall be surveyed by a wildlife biologist within the seven days immediately prior to ground disturbing activities.

The undisturbed ground cover to 50 feet beyond the planned disturbance, or to the right of way line, whichever is less, shall be maintained at a height of 6 inches or less beginning April 1 and continuing until August 31 or until the end of ground disturbance work, whichever comes first.

If birds establish a nest within the survey area, an appropriate buffer of 50 feet will be established around the nest by the CDOT biologist. This buffer dimension may be changed if determined appropriate by the CDOT biologist and approved by the Engineer.

The Contractor shall install fence (plastic) at the perimeter of the buffer. Work shall not proceed within the buffer until the young have fledged or the nests have become inactive.

If the fence is knocked down or destroyed by the Contractor, the Engineer will suspend the work, wholly or in part, until the fence is satisfactorily repaired at the Contractor's expense. Time lost due to such suspension will not be considered a basis for adjustment of time charges, but will be charged as contract time.

- (b) *Work on structures.* The Contractor shall prosecute work on structures in a manner that does not result in a taking of migratory birds protected by the Migratory Bird Treaty Act (MBTA). The Contractor shall not prosecute the work on structures during the primary breeding season, April 1 through August 31, unless he takes the following actions:
 1. The Contractor shall remove existing nests prior to April 1. If the Contract is not awarded prior to April 1 and CDOT has removed existing nests, then the monitoring of nest building shall become the Contractor's responsibility upon Notice to Proceed.
 2. During the time that the birds are trying to build or occupy their nests, between April 1 and August 31, the Contractor shall monitor the structures at least once every three days for any nesting activity.
 3. If the birds have started to build any nests, they shall be removed before the nest is completed. Water shall not be used to remove the nests if nests are located within 50 feet of any surface waters.

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**REVISION OF SECTION 240
PROTECTION OF MIGRATORY BIRDS
BIOLOGICAL WORK PERFORMED BY THE CONTRACTOR'S BIOLOGIST**

4. Installation of netting may be used to prevent nest building. The netting shall be monitored and repaired or replaced as needed. Netting shall consist of a mesh with openings that are $\frac{3}{4}$ inch by $\frac{3}{4}$ inch or less.

If an active nest become established, i.e., there are eggs or young in the nest, all work that could result in abandonment or destruction of the nest shall be avoided until the young have fledged or the nest is unoccupied as determined by the wildlife biologist and approved by the Engineer. The Contractor shall prevent construction activity from displacing birds after they have laid their eggs and before the young have fledged.

If the project continues into the following spring, this cycle shall be repeated. When work on the structure is complete, the Contractor shall remove and properly dispose of netting used on the structure.

- (c) *Taking of a Migratory Bird.* The taking of a migratory bird shall be reported to the Engineer. The Contractor shall be responsible for all penalties levied by the U. S. Fish and Wildlife Service (USFWS) for the taking of a migratory bird.

**REVISION OF SECTION 304
AGGREGATE BASE COURSE**

Section 304 of the Standard Specifications is hereby revised for this project as follows:

Subsection 304.02 shall include the following:

Materials for the base course shall meet the gradation requirements for Aggregate Base Course (Class 6) as shown in subsection 703.03.

The aggregate base course (Class 6) must meet the gradation requirements and have a resistance value of at least 77 when tested by the Hveem Stabilometer method.

**REVISION OF SECTION 304 AND 403
TICKET COLLECTION FOR AGGREGATE BASE COURSE AND HOT MIX ASPHALT**

Section 304 and 403 of the Standard Specifications is hereby revised for this project as follows:

Subsection 304.08 and 403.05 shall include the following:

The Contractor shall collect the scale ticket on each load when it is delivered to the project site, and ensure that the information required in subsection 109.01 is shown on each ticket:

The scale tickets shall be available on site for CDOT personnel to inspect.

Each day the Contractor shall provide to the Engineer envelopes, which contain the previous day's signed tickets and the following:

1. On each envelope: Project number, date of paving, type of material, beginning and ending station, daily total and cumulative total.
2. One of the following:
 - A. Two adding machine tape tabulations of the weight tickets with corresponding totals run and signed by different persons,
 - B. One signed adding machine tape tabulation of the weight tickets that has been checked and signed by a second person,
 - C. Signed check tape of computer scale tickets that have a cumulative total. These scale tickets must be consecutive and without voids adjustments.
3. A listing of any overweight loads on the envelope, including ticket numbers and amount over legal limit.
4. A comparison of the actual yield for each day's placement to the theoretical yield. Theoretical yield shall be based on the actual area paved, the planned thickness, and the actual density of the mixture being placed. Any variance greater than +/- 2.5% shall be indicated on the envelope and a written explanation included.

The Contractor shall provide a vehicle identification sheet that contains the following information for each vehicle:

- (1) Vehicle number
- (2) Length
- (3) Tare weight
- (3) Number of axles
- (4) Distance between extreme axles
- (5) All other information required to determine legal weight.
- (6) Legal weight limit.

If the Contractor fails to provide the Engineer with the required information on a daily basis, paving will not be allowed to resume unless approved by the Engineer.

**REVISION OF SECTION 401
HOT MIX ASPHALT COMPACTION
(PNEUMATIC TIRE ROLLERS)**

Section 401 of the Standard Specifications is hereby revised for this project as follows:

In subsection 401.17, first paragraph, delete the second sentence and replace with the following:

Both steel wheel and pneumatic tire rollers will be required on this project. If the Contractor has demonstrated that all of the manufacturer's recommendations were followed and the pneumatic tire roller is detrimental to the finished surface of the HMA, the Engineer, in cooperation with the Contractor and the Region Materials Engineer, may waive the pneumatic tire roller requirement.

**REVISION OF SECTION 403
 HOT MIX ASPHALT**

Section 403 of the Standard Specifications is hereby revised for this project as follows:

Subsection 403.02 shall include the following:

The design mix for hot mix asphalt shall conform to the following:

Table 403-1							
Property	Test Method	Value For Grading					
				SX(100)			Patching
Air Voids, percent at: N (design)	CPL 5115			3.5 – 4.5			3.5 – 4.5
Lab Compaction (Revolutions): N (design)	CPL 5115			100			100
Stability, minimum	CPL 5106			30			30
Aggregate Retained on the 4.75 mm (No. 4) Sieve for S, SX and SG, and on the 2.36mm (No. 8) Sieve for ST and SF with at least 2 Mechanically Induced fractured faces, % minimum*	CP 45			70			70
Accelerated Moisture Susceptibility Tensile Strength Ratio (Lottman), minimum	CPL 5109 Method B			80			80
Minimum Dry Split Tensile Strength, kPa (psi)	CPL 5109 Method B			205 (30)			205 (30)
Grade of Asphalt Cement, Top Layer				PG 76- 28			
Grade of Asphalt Cement, Layers below Top				PG 64- 22			PG 64-22
Voids in the Mineral Aggregate (VMA) % minimum	CP 48			See Table 403-2			See Table 403-2
Voids Filled with Asphalt (VFA), %	AI MS-2			65-75			65-75

Table 403-1

Property	Test Method	Value For Grading					
				SX(100)			Patching
Dust to Asphalt Ratio	CP 50						
Fine Gradation				0.6 – 1.2			0.6 – 1.2
Coarse Gradation				0.8 – 1.6			0.8 – 1.6
<p>Note: AI MS-2 = Asphalt Institute Manual Series 2</p> <p>Note: Mixes with gradations having less than 40% passing the 4.75 mm (No. 4) sieve shall be approached with caution because of constructability problems.</p> <p>Note: Gradations for mixes with a nominal maximum aggregate size of one-inch or larger are considered a coarse gradation if they pass below the maximum density line at the #4 screen. Gradations for mixes with a nominal maximum aggregate size of 3/4" to 3/8" are considered a coarse gradation if they pass below the maximum density line at the #8 screen. Gradations for mixes with a nominal maximum aggregate size of #4 or smaller are considered a coarse gradation if they pass below the maximum density line at the #16 screen.</p> <p>*Fractured face requirements for SF may be waived by RME depending on project conditions.</p>							

All mix designs shall be run with a gyratory compaction angle of 1.25 degrees and properties must satisfy Table 403-1. Form 43 will establish construction targets for Asphalt Cement and all mix properties at Air Voids up to 1.0 percent below the mix design optimum.

Table 403-2

Nominal Maximum Size*, mm (inches)	Minimum Voids in the Mineral Aggregate (VMA)			
	***Design Air Voids **			
	3.5%	4.0%	4.5%	5.0%
37.5 (1½)	11.6	11.7	11.8	N/A
25.0 (1)	12.6	12.7	12.8	
19.0 (¾)	13.6	13.7	13.8	
12.5 (½)	14.6	14.7	14.8	
9.5 (⅜)	15.6	15.7	15.8	
4.75 (No. 4)	16.6	16.7	16.8	16.9
	<p>* The Nominal Maximum Size is defined as one sieve larger than the first sieve to retain more than 10%.</p> <p>** Interpolate specified VMA values for design air voids between those listed.</p> <p>*** Extrapolate specified VMA values for production air voids beyond those listed.</p>			

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REVISION OF SECTION 403
HOT MIX ASPHALT

The Contractor shall prepare a quality control plan outlining the steps taken to minimize segregation of HMA. This plan shall be submitted to the Engineer and approved prior to beginning the paving operations. When the Engineer determines that segregation is unacceptable, the paving shall stop and the cause of segregation shall be corrected before paving operations will be allowed to resume.

CDOT approved Warm Mix Asphalt (WMA) may be allowed on this project in accordance with CP 59. Unique requirements for WMA design, production and acceptance testing as documented during CDOT WMA approval shall be submitted and approved prior to creation of the Form 43 and before any WMA production on the project. Delays to the project due to WMA submittal and review will be considered within the Contractor's control and will be non-excusable.

Hot mix asphalt for patching shall conform to the gradation requirements for Hot Mix Asphalt (Grading SX).

A minimum of 1 percent hydrated lime by weight of the combined aggregate shall be added to the aggregate for all hot mix asphalt.

Acceptance samples shall be taken at the location specified in either Method B or C of CP 41.

Subsection 403.03 shall include the following:

If liquid anti-stripping additive is added at the plant, an approved in-line blender must be used. The blender shall be in the line from the storage tank to the drier drum or pugmill. The blender shall apply sufficient mixing action to thoroughly mix the asphalt cement and anti-stripping additive.

The Contractor shall construct the work such that all roadway pavement placed prior to the time paving operations end for the year, shall be completed to the full thickness required by the plans. The Contractor's Progress Schedule shall show the methods to be used to comply with this requirement.

Aggregate, asphalt recycling agent, additives, hydrated lime, and all other work necessary to complete each hot mix asphalt item will not be paid for separately, but shall be included in the Lump Sum bid. When the pay item includes the PG binder grade, the asphalt cement will not be measured and paid for separately, but shall be included in the work. Asphalt cement used in Hot Mix Asphalt (Patching) will not be measured and paid for separately, but shall be included in the work.

**REVISION OF SECTION 601
CLASS D (SPECIAL) SHRINKAGE COMPENSATING CONCRETE**

Section 601 of the Standard Specifications is hereby revised for this project as follows:

Subsection 601.02 shall include the following:

Concrete Class	Required Field Compressive Strength (psi)	Cementitious Material Content: Minimum or Range (lbs/cu.yd.	Air Content: % Range (total)	Water/Cementitious Material Ratio: Maximum or Range
D (Special)	4500 at 28 days	500 to 700 or Minimum	5 – 8	0.45-0.55

Class D (Special) is a shrinkage compensating concrete used for bare concrete bridge decks. Additional requirements are:

- (1) An expansive cement additive shall be added to an ASTM C150 Type I/II cement and fly ash to produce an ASTM C845 Type K cement. Approximately 15-20 percent by weight of the cementitious content of the concrete will be the expansive cement additive. The proportion of the expansive cement additive will be determined by testing the cementitious material blend in accordance with ASTM C806. The blended material shall have an expansion of 0.04 to 0.10 percent at 7-days when tested in accordance with ASTM C806.
- (2) The expansion of the laboratory trial mix shall be 0.05 to 0.09 percent at 7 days when tested in accordance with ASTM C878.
- (3) The permeability of the laboratory trial mix shall not exceed 2000 coulombs at 56 days when tested by ASTM C 1202
- (4) The sulfate exposure is Class 0 when used for bridge deck concrete. The maximum water to cementitious material ratio shall not apply for Class 0.

In subsection 601.07, second paragraph add the following:

For Class D (Special) concrete, water shall not be added after the initial mixing. All water shall be added at the plant. Slump adjustment shall be through the addition of an approved water reducing admixture.

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**REVISION OF SECTION 601
CLASS D (SPECIAL) SHRINKAGE COMPENSATING CONCRETE**

In subsection 601.15 delete (b) and (c) and replace with the following:

- (b) *Test Slab.* At least fourteen working days prior to initial placement of Class D (Special), Class H, Class HT or Class S50 concrete on or in a deck, the Contractor shall place, finish and cure a test slab according to the project specifications, using the same personnel, methods and equipment (including the concrete pump, if used) that will be used on the bridge deck. The test slab shall be the same width as the bridge deck. When the bridge deck width is greater than 40 feet, the Contractor may reduce the test slab width to a minimum of 40 feet. The test slab shall have a length of at least 30 feet and shall have a thickness a minimum of the bridge deck thickness. Placement of Class D (Special), Class H, HT or S50 Concrete in the deck shall not occur until written approval is received from the Engineer. Approval to place concrete on the deck will be based on satisfactory placement, consolidation, finishing and curing of the test slab and cores, and will be given or denied within two working days of receiving the cores from the Contractor.

A minimum of one day after construction of the test slab, the Contractor shall core four full-depth 4 inch diameter cores, one from each quadrant of the test slab, and submit them to the Engineer for visual inspection of degree of consolidation. . If an additional test slab is deemed necessary by the Engineer, it shall be placed at the Contractor's expense.

Additional test slabs shall be placed as necessary to verify changes in design or procedures at the Contractor's expense.

Test slabs that are placed as acceptable work in segments of concrete pavement, or as approach slabs, or other locations acceptable to the Engineer, will be paid for as the pay item for that element of the Contract.

- (c) *Placing.* Concrete shall be placed in accordance with the requirements of subsection 601.12 except for the following:

Concrete shall be placed in such manner as to require as little handling as possible and at sufficient depth to provide adequate material for screeding and finishing operations. The concrete shall be discharged as near its final location as practicable. The pattern of placement shall be such that lateral flow will be minimized. Concrete shall be placed against the leading edge of fresh concrete where practicable.

For Class D (Special), Class H, HT and S50 Concrete maintain environmental conditions on the entire bridge deck so the evaporation rate is less than 0.2 pounds per square foot per hour. The temperature of Class D (Special), Class H, HT and S50 Concrete immediately before placement shall be a minimum of 55°F and a maximum of 70°F. This may require placing the deck at night, in the early morning or on another day. The evaporation rate (as determined in the American Concrete Institute Manual of Concrete Practice 305R, Chapter 2) is a function of air temperature, concrete temperature, wind speed and relative humidity. The effects of any fogging required by the Engineer will not be considered in the estimation of the evaporation rate.

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**REVISION OF SECTION 601
CLASS D (SPECIAL) SHRINKAGE COMPENSATING CONCRETE**

Concrete temperature shall not exceed 90°F during placing and finishing activities. The contractor shall provide methods of tracking concrete temperature and measures shall be taken to maintain the temperature.

Just prior to and at least once every hour during placement of the Class D (Special), Class H, HT and S50 Concrete and until the water cure method is applied, the Contractor shall measure, record and report to the Engineer the air temperature, concrete temperature, wind speed, and relative humidity on the bridge deck. The Contractor will take and report to the Engineer the air temperature, wind, and relative humidity measurements approximately 12 inches above the surface of the deck. With this information, the Engineer will determine the evaporation rate.

When the evaporation rate is equal to or above 0.2 pounds per square foot per hour, the Contractor shall take actions (such as cooling the concrete, installing wind breaks, sun screens, etc.) to create and maintain an evaporation rate less than 0.2 pounds per square foot per hour on the entire bridge deck.

Fogging using hand-held equipment may be required by the Engineer during unanticipated delays in the placing, finishing or curing operations. If fogging is required by the Engineer, the Contractor shall not allow water to drip, flow or puddle on the concrete surface during fogging, placement of absorptive material, or at any time before the concrete has achieved final set. The effects of fogging required by the Engineer will not be considered in the estimation of the evaporation rate.

Longitudinal joints for a Class HT concrete overlay will be allowed only at the locations of lane lines as approved by the Engineer.

If placing Class D (Special), Class H, HT and S50 Concrete is delayed and the concrete has taken its initial set, the placement shall be stopped. The Contractor shall saw the nearest construction joint approved by the Engineer, and remove all concrete beyond the construction joint.

Transverse joints may be utilized when the Engineer determines that the work is not progressing in a satisfactory manner, or when required by change in weather conditions. The Engineer may approve transverse joint locations to accommodate phased overlay construction.

Subsection 601.16 shall include the following:

For Class D (Special), concrete the minimum curing period shall be 168 hours.

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**REVISION OF SECTION 601
CLASS D (SPECIAL) SHRINKAGE COMPENSATING CONCRETE**

(g) Class D (Special) concrete shall be cured as follows:

Water Cure Method. The water cure method shall be applied as soon as it can be without marring the surface. The surface of the concrete, including bridge curbs and bridge sidewalks, shall be entirely covered with wet burlap and polyethylene sheeting. Prior to being placed, the burlap shall be thoroughly saturated with water. The wet burlap and polyethylene sheeting shall extend at least twice the thickness of the bridge deck beyond the edges of the slab and shall be weighted to remain in contact with the surface. The wet burlap and polyethylene sheeting shall remain in contact and be kept wet for the entire curing period

**REVISION OF SECTION 601
CONCRETE PATCHING**

Section 601 of the Standard Specifications is hereby revised for this project as follows:

601.02 Concrete (Patching). This work consists of furnishing and placing material in accordance with these specifications and in conformity with the lines, grades and dimensions as shown on the plans or established.

Materials for concrete patching shall be from the list shown on the department's Approved Product List, category: concrete, repair/patching, rapid set, horizontal or an approved equal. This list may be viewed at the following internet link: <http://www.coloradodot.info/business/apl> <http://apps.coloradodot.info/apl/AplSearch.cfm> . Concrete patching material shall have an average compressive strength of 4000 psi at 24 hours.

Concrete patching material may be extended only in accordance with the manufacturer's recommendations. The Contractor shall submit a report consisting of the mix proportions and compressive strength information. Compressive strength measurements shall be taken at one hour, three hours, six hours, 24 hours, 7 days and 28 days according to ASTM C 39 Compressive Strength of Cylindrical Concrete Specimens. Test results shall be the average of at least three specimens molded according to AASHTO T 126 Making and Curing Concrete Test Specimens in the Laboratory

Concrete patching material shall be placed and consolidated to fill removed concrete. The surface of concrete patching material shall be smooth and match the surrounding concrete surfaces. Concrete patching material shall not extend above a waterproofing membrane.

Portions of bridge decks patched with Concrete (Patching) shall not be opened to traffic until the Contractor demonstrates that the concrete patching material has reached a compressive strength of 3000 psi with a calibrated rebound hammer according to ASTM C 805 Rebound Number of Hardened Concrete.

**REVISION OF SECTION 603
CULVERTS AND SEWERS**

Subsection 603.07(a) shall include the following:

Joints for all circular reinforced pipe shall be made with confined rubber gaskets. Concrete collars shall be required at all nonstandard joints (not tongue and groove or bell and spigot), and at all connections to existing pipe.

**REVISION OF SECTION 613
ELECTRICAL CONDUCTOR IDENTIFICATION**

Section 613 of the Standard Specifications is hereby revised for this project as follows:

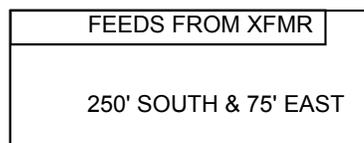
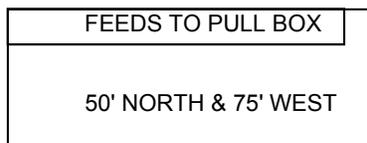
Section 613.08 shall include the following:

All electrical conductors shall be tagged as follows:

Electrical conductor cable tags shall be located below the termination in the base of the street light, in the pull box, in the pedestal and at the point of termination to existing facilities of the Local Utility Company supplying electrical service. The tags shall be attached with a cable tie. The information written on the tag shall include the direction and approximate length of cable feeds running from where to, etc.

Each incoming conductor shall be individually color coded with 1 tape mark, while outgoing conductors shall have 2 tape marks.

Example:



Uniform tags are available in a Tag Kit. The Tag Kit consists of: 100 tags, 3 part yellow with 1 hole, 100 black nylon ties and 1 black sharpie pen.

Size	2-1/2" X 5"
Standard Package	Kit
Weight, Kit, Approx.	1.5 Pounds
Color	Yellow

Electrical conductor tagging will not be paid for separately, but shall be included in the cost of the Electrical Conduit and all associated equipment installation.

**REVISION OF SECTION 613
ELECTRICAL CONDUIT**

Section 613 of the Standard Specifications is hereby revised for this project as follows:

DESCRIPTION

This work includes furnishing and installing either (HDPE) High Density Polyurethane or PVC electrical conduit. All materials furnished, assembled, fabricated and installed under this item shall be new, corrosion resistant and in strict accordance with the plan sheets and these Special Provisions.

MATERIALS

All conduits shall be Schedule 80 in the diameters, quantities and colors as shown on the project detail sheet and shall be compliant with all ASTM and Bellcore TW-NWT-000356 requirements.

All HDPE conduit shall be factory lubricated, low friction, high-density conduit constructed of virgin high-density polyethylene resin. Conduit shall be capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation, without affecting its properties or performance.

PVC conduit shall be certified by the manufacturer as meeting ANSI/UL 6 and 651. The manufacturer shall be ISO 9000 compliant.

CONSTRUCTION

Electrical Conduit (Bored) shall be HDPE and installed using a trenchless technology of either jacked conduit or directional boring.

Electrical Conduit (Plastic) shall be PVC or HDPE and installed by direct burial methods such as plowing, open trenching, or other excavation methods. When PVC is used, expansion fittings shall be installed at 100' intervals.

One conduit per bundle shall have a copper tracer wire of at least 12-gauge in a single conduit. In trenches containing multiple conduits, the tracer wire shall not be installed in the same conduit as the fiber.

Each individual conduit shall be equipped with a pull tape of 1250 pounds tensile strength and be of a design to prevent cutting or burning of conduit walls during cable installation.

CONSTRUCTION REQUIREMENTS

The installation of conduit shall be performed in such a manner as to avoid unnecessary damage to streets, sidewalks, utilities, landscaping, and sprinkler systems. Excavations and conduit installation shall be performed in a continuous operation. All trenches shall be backfilled by the end work day. The material from trenching operations shall be placed in a location that will not cause damage or obstruction to vehicular or pedestrian traffic or interfere with surface drainage.

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REVISION OF SECTION 613
ELECTRICAL CONDUIT

The Contractor shall take all necessary precautions to avoid heaving any existing asphalt/concrete mat or over-excavating a trench, whether caused by equipment directly or by dislodging rocks and boulders. Any such heaving or over-excavation shall be repaired or replaced at the Contractor's expense. The Contractor shall bear the cost of backfilling all over-excavated areas with the appropriate backfill material as approved by the project engineer.

The Contractor shall restore all surface materials to their preconstruction condition, including but not limited to pavement, sidewalks, sprinkler systems, landscaping, shrubs, sod, or native vegetation that is disturbed by the conduit installation operation. All repairs shall be included in the cost of the conduit.

If the Contractor is unable to bore the conduit at the lengths shown on the plans from access point to access point, all splice couplings and associated work to splice conduit shall be included in the cost of this item. The coupling technology shall allow the conduit to be connected without the need for special tools, and shall form a watertight, airtight seal. Breaking force between segments shall exceed 250 pounds of force. No metal fittings shall be allowed. No elevation difference between the conduit run and the splice location will be allowed. Conduit splices shall be kept to a minimum and all locations shall be approved by the project engineer. Additional pull boxes shall not be substituted for splices.

Conduit plugs shall be supplied and installed in all conduit ends as soon as the conduit is installed. Conduit shall be plugged at all termination points such as pull boxes, manholes, controller cabinets, and node buildings. Conduits containing cable shall be plugged with durable and reusable split type plugs, fabricated without metallic parts, and allow easy removal and reinstallation around in-place cables. Split type plugs shall provide a water and air-tight seal of at least 50 psi and shall be installable by hand without using special tools and without damaging the cable. All plugs shall be correctly sized to fit the conduit being plugged. Empty conduits shall be sealed with removable type duct plugs that provide a watertight barrier.

All conduits shall use sweeps to elevate the buried conduits to within 4 inches of the bottom of the pull box or manhole, as shown in project details. The sweeps shall be terminated within the pull boxes and manholes to allow for easy installation and removal of the conduit plugs. The sweeps shall be set above the ground surface within the pull box at a height that does not interfere with the coiling of the fiber optic cable.

All conduit runs containing fiber optic cable shall have a limited number of bends. The sum of the individual conduit bends on a single conduit run between two pull boxes shall not exceed 360°. The preferred limit is 270°. No individual bend shall be greater than 90°. All conduit bends shall have a minimum acceptable radius. The minimum radius for 90° bends is 48 inches, and the minimum radius for all other bends is 24 inches.

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**REVISION OF SECTION 613
ELECTRICAL CONDUIT**

If new conduits are installed in existing pull boxes, manholes or cabinet bases the Contractor shall carefully excavate around the pull box or manhole and install the new conduit as shown in the plans. The Contractor shall not damage the existing pull box, manhole or their contents. If the existing pull box, lid, or the concrete collars are cracked or damaged during conduit installation, the Contractor shall restore the damaged section to preconstruction condition at no additional cost.

METHOD OF MEASUREMENT

Electrical Conduit shall include all electrical wire and/or telephone wire per end equipment requirements. Conduit shall also include anchors, bands, skids, sweeps, pull tape, copper tracer wire, adapters, expansion couplings, conduit plugs, installation equipment, adhesives, labor, and all other items necessary to complete the work.

**REVISION OF SECTION 613
PULL BOXES**

Section 613 of the Standard Specifications is hereby revised for this project as follows:

DESCRIPTION

Contractor shall furnish and install fiberglass reinforced, polymer concrete pull boxes.

MATERIALS

Pull boxes installed in dirt or landscaped areas shall have a concrete apron with 3 sides, 12 inches wide by 6 inches deep and a top side of 18 inches wide by six inches deep for marker installation. Pull boxes shall not be installed above the grade of the apron. Concrete apron shall have a 1% slope away from the top of pull box. All concrete aprons shall be Class B and shall be in accordance with Section 601.

Pull boxes shall have a detachable cover with a skid-resistant surface and have the words "CDOT COMM" cast into the surface. Painting of words shall not be accepted. The cover shall be attached to the pull box body by means of 3/8 x 7 inch lag head stainless steel hex head bolts and shall have two (2) lift slots to aid in the removal of the lid.

Wire mesh shall be installed in a manor to completely surround the box. The wire mesh shall meet the material standard ANSI/ASTM A555-79 and made of T-304 stainless steel, 0.025 inch wire diameter minimum and shall have a spacing of 12 mesh per inch.

Pull boxes shall be verified by a 3rd Party Nationally Recognized Independent Testing Laboratory as meeting all test provisions of ANSI/SCTE 77 2007 Specification for Underground Enclosure Integrity, Tier 22 rating. Pull boxes shall be UL listed. Certification documents shall be submitted with material submittals.

CONSTRUCTION

A minimum of 12 inches of ¾ inch granite-gravel shall be installed as a base for the pull box to aide in drainage. The ¾ inch granite-gravel shall be free of dirt and debris and spread evenly to facilitate a level base for the pull box. The Contractor shall ensure that sufficient compacting is made prior to the installation of ¾ inch granite-gravel to help alleviate future settling.

Wire mesh shall be installed in a manor to completely surround the box. The wire mesh shall be installed prior to the installation of the pull box above the bed of 3/4" granite-gravel and extending one foot past the outer edges of the concrete apron. The wire mesh shall be gently cut to allow only the entrance of the conduit at the bottom of the box. Any openings cut in the wire mesh larger than the diameter of the conduit shall be remedied by the installation of additional wire mesh to obtain a completely sealed pull box enclosure.

Pull Box (Surface Mounted) shall be aluminum type with a hinged front door and have at least a NEMA 3R rating. The hinged door shall be provided with both a weather tight seal and an aluminum hasp. Surface mounted pull boxes shall be of the dimensions shown in the plans, and shall be mounted on or embedded into hard surfaces such as bridge decks, concrete barriers, retaining walls, or buildings, as shown on the plans. Surface mounted pull boxes shall be attached using 3/8-inch epoxy anchors or other methods, as approved by the Engineer. Surface mounted pull boxes shall not be used for ground installations.

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REVISION OF SECTION 613
PULL BOXES

METHOD OF MEASUREMENT

Pull Boxes will be measured by the actual number that are installed and accepted, and will include base, lid, excavation, backfill, concrete apron, wire mesh and 3/4" granite-gravel. Pull Boxes shall also include the removal and patching of pavement, sidewalks, curb and gutters and their replacement in kind to match existing grade.

**REVISION OF SECTION 614
BUFFER TUBE FAN OUT KIT**

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project, the Buffer Tube Fan Out Kit shall be furnished and installed on fiber lateral cable ends in field termination panels mounted within communication cabinets.

MATERIALS

The Contractor shall use fiber optic fan out kits on the fiber lateral cable in the communication cabinet termination panels. Fan out buffer tubes for the lateral fiber strands shall be 9mm minimum and shall be neatly coiled after installation and secured within the field termination panels. Fan out kits shall be supplied with buffer tubes matching the lateral fiber strand colors. ST type bulkhead connectors shall be terminated on the ends of the lateral cable fiber strands and installed on the back side of the termination panel bulkheads. The connectors shall have a ceramic ferrule with a nickel-plated nut and body. The connector shall be polished with a physical contact (PC) finish.

**REVISION OF SECTION 614
CLOSED CIRCUIT TELEVISION**

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing an Internet Protocol (IP) Closed Circuit Television (CCTV) camera at the locations shown on the Plans.

MATERIALS

The CCTV camera shall include: camera with weatherproof dome housing, pole mount adapter, Power over Ethernet (PoE) midspan module, manufacturer supplied management software, Cat-6 Ethernet cables, and all attachment hardware to complete installation.

Camera Specifications –

The pan-tilt-zoom camera shall be of dome type construction and shall be enclosed in a sealed, heated environmental video dome housing to operate in 100% humidity at a minimum operating temperature of -40° to 122°F carrying both IP66 and NEMA 4x ratings. The camera shall utilize Ethernet protocol for native communications and be capable of sending multiple individually configurable video streams in H.264 and MJPEG format up to 30fps and capable of gathering a minimum of 50 preset color video still frame images with a minimum 176x120 resolution and maximum 704x480. The camera shall have an internal web interface for configuration with security functionality allowing multiple user access levels with password protection. The camera shall support Ipv4/v6, HTTP, HTTPS, SSL/TSL, QOS Layer 3 DiffServ, FTP, SMTP, SNMP v1/2/3, UpnP, DNS, DynDNS, NTP, RTSP, TCP, UDP, IGMP, RTCP, ARP, SOCKS.

Technical specifications for the camera shall be as follows:

- The lens shall be f=3.4 to 119mm, F1.4 to 4.2, autofocus; focus range of 35 mm (wide) to 800 mm (telephoto) to infinity. The angle of view shall be 2.8°- 48° horizontal with minimum zoom capability of 35x optical and 12x digital
- Minimum illumination color 0.5 lux at 30 IRE and B/W 0.005 lux at 30 IRE
- The camera shall provide dual mode, day (color) and night (monochrome) video down to 0.008 lux
- Shutter speed shall be variable from 1/30000 to 0.5 seconds at 60Hz.
- The pan function shall provide 360° of continuous rotation at 0.05 – 450°/s and a 220° tilt range allowing for 20° view above the horizon at 0.05 – 450°/s

Pole mount adapter arm and bracket -

The adapter shall have a minimum 33 lb load rating and have provisions that allow mounting directly to the weatherproof dome housing without modification to the housing. The adapter bracket shall have slots for a minimum of 2 straps or banding material for mounting to the poles from 3 inches to 6 inches in diameter. The bracket shall have cable strain relief in at least two locations on the reverse side, (between the bracket and the pole).

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**REVISION OF SECTION 614
CLOSED CIRCUIT TELEVISION**

PoE midspan module-

Power for the camera shall be by means of a high power over Ethernet midspan module with a pass through port for all Ethernet communications. The module shall meet IEEE 802.3at and 802.3af standards and operate at temperatures from -40°F to +122°F. The PoE module shall allow 100-240 VAC input and 55 VDC output at 60W and operate at temperatures from -40°F to +122°F.

Manufacturers supplied management software-

Management software shall give the user access to discover and configure the camera using standard network protocols. Software shall allow for network setup and firmware updates.

Cat6 Ethernet cable-

Cable shall be a UTP cable, Category 6 rated and constructed of 24 AWG stranded copper wires. The outer jacket shall be UV resistant PVC insulation. The Ethernet cable shall be terminated with male 8P8C connectors as a 'straight through' cable using the Telecommunications Industry Association / Electronic Industries Alliance (TIA/EIA) T- 568B pin/pair assignments.

CONSTRUCTION REQUIREMENTS

The CCTV camera shall be installed in accordance with these specifications, the details shown in the Plans, and in accordance with manufacturer's recommendations. The Contractor shall make all arrangements for a qualified manufacturer's representative to be on-site to ensure proper installation of the CCTV camera.

The weatherproof dome housing shall be attached to the pole mount adapter using the materials supplied from the manufacturer.

For the attachment of the adapter bracket to the pole, a ¾ inch type 201 stainless steel strap used in conjunction with type 201 stainless steel buckles at a mounting height shown on the Plans. The attachment shall be banded to the pole at an orientation to achieve the optimal view of both the main roadway and crossroad or as directed by the Engineer.

A maximum 1 inch hole shall be drilled in the mounting pole to allow passage of the Ethernet cable. The hole shall be free of burs and sharp edges prior to the installation of the Ethernet cable. The Ethernet cable shall be attached to the reverse side of the mounting bracket to ensure proper strain relief or damage caused to the camera or housing. The Ethernet cable shall run down the interior of the pole and exit through non-metallic flexible conduit to the communication cabinet. The non-metallic flexible conduit shall be weather sealed on each end to eliminate exterior liquid entry. The Contractor shall also provide a weather seal for the adapter bracket at the 1 inch hole at the top of the pole per the manufacturer's recommendations.

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**REVISION OF SECTION 614
CLOSED CIRCUIT TELEVISION**

The PoE midspan module shall be securely mounted in the communication cabinet and plugged into the communications power outlet. The Ethernet cable attached to the camera shall be connected to the PoE midspan output jack. A separate Cat 6 Ethernet cable shall be provided for connection to the field communication device.

METHOD OF MEASUREMENT

Closed Circuit Television will be measured by the actual number of Closed Circuit Televisions installed and accepted for a complete installation. Also included shall be all configuration, cabling, dome housing, adaptor arm, adaptor bracket, and PoE midspan module. All costs associated with arranging for the manufacturer's representative to be on-site will not be measured and paid for separately, but shall be included with the cost of the CCTV.

**REVISION OF SECTION 614
COMMUNICATION CABINET**

Section 614 of the Standard specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing communications cabinets at designated Intelligent Transportation System (ITS) field device locations to house and protect electrical power components as shown on the Plans.

MATERIALS

Communications Cabinets. Communications cabinets shall be UL 508A Industrial Control Panels listed and conform to a NEMA Type 4X rating. Communications cabinets shall be constructed of 0.125 inch Type 5052 H-32 aluminum conforming to the requirements of ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate. The dimensions shall be as shown in Table 1 below.

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**Table 1
COMMUNICATIONS CABINET TYPES**

Communications Cabinet	Dimensions	Maximum Weight (w/o back panel)
Type 1	30 inches (H) × 24 inches (W) × 8 inches (D)	30 lb
Type 2	36 inches (H) × 24 inches (W) × 12 inches (D)	40 lb

All bolts, clamps, fasteners, hinges, latches, nuts and screws shall be stainless steel, unless an alternative corrosion proof material is approved in writing by the Department.

A cabinet grounding stud shall be provided in the vicinity of the ground bus mounted on the back panel as shown on the Plans.

Each communications cabinet, designated for mounting on a pole, shall include a pole mounting kit suitable for pole diameters ranging from seven to 12 inches. Each pole mounting kit shall include channel bars (for attachment to factory mounting holes on the back of the communications cabinet), pole shims (to prevent cabinet movement against pole), stainless steel straps and all other associated mounting and sealing hardware. The stainless steel straps and buckles shall be constructed of Type 201 stainless steel and have a width of 3/4 inch. The channel bars, pole shims and associated mounting hardware shall be manufactured from either galvanized steel or stainless steel.

Each communications cabinet shall include the following:

- (a) *Back Panel.* Each back panel shall be constructed of either 12 gauge steel with a conductive, corrosion-resistant coating or ≥ 0.19 inch Type 5052-H32 aluminum alloy. One back panel and associated mounting hardware shall be included with each communications cabinet and be rated for use in NEMA 4X cabinets. The back panel shall be not less than 27 inches (h) × 21 inches (h). The back panel shall be mounted within the communications cabinet with a minimum of four screws that are provided with each communications cabinet. A ground bus shall also be provided with each back panel for mounting at the location shown on the plans.

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**REVISION OF SECTION 614
COMMUNICATION CABINET**

- (b) *Device Box with GFCI Receptacles.* Each communications cabinet shall contain a single gang device box attached to the back panel as shown in the Plans. Each device box shall be constructed of metal in conformance with Articles 314.40 and 314.44 of the NEC. The depth of each device box shall be sufficient to accommodate the depth of the GFCI receptacle and provide adequate free space for all enclosed conductors as specified in Article 314.16 of the NEC. Each junction box shall include knockouts and clamps for conduit and cables. Covers shall be provided for each device box as appropriate for the duplex GFCI receptacles and shall be consistent with the requirements of Article 314.41 of the NEC.

Duplex NEMA 5-15R GFCI receptacles shall be provided within the device box as specified in the Plans. NEMA 5-15R GFCI receptacles shall be rated for 125 VAC, 0.5 HP and 15 A. It shall be of commercial grade quality and manufactured from high strength nylon. NEMA 5-15R GFCI receptacles shall have two poles, three wires, a manual reset button and a self-test button.

Duplex NEMA 5-15R GFCI receptacles shall conform to Article 210.8 of the NEC and be UL listed.

- (c) *Power Conditioner with Power Strip.* The power conditioner shall be a Clary SP400U Universal Power Conditioner. The power conditioner has a unit weight of 5 pounds and its dimensions are 1.7 inches (H) × 11 inches (W) × 8.5 inches (D). An integral component of the power conditioner shall be a factory-installed power strip. The power strip shall have six front facing NEMA Type 5-15R outlets. The power strip shall be rated for 15 A at 120 VAC. It shall have an energy rating of 630 Joules, clamping voltage of 500 V and EMI/RFI noise filter of 150 KHz to 100 MHz at up to 43 dB. The power strip shall have a recessed power switch and a power cord of not less than 2.5 feet. The dimensions of the power strip shall be 10 inches (L) × 1.63 inches (W).

One power conditioner with power strip shall be provided with each communications cabinet.

- (d) *Deutsche Institut fur Normung (DIN) Rails.* Each communications cabinet shall utilize standard 1.38 inch DIN rails. The DIN rails shall be of steel construction with a coating for corrosion resistance. The DIN rails shall utilize 0.25 inch × 0.71 inch slots for fastening to the back panel located in each communications cabinet. The spacing of the DIN rail slots shall be 0.98 inch center-to-center. DIN rails and associated mounting hardware for attachment to the back panel shall be provided with each communications cabinet in the lengths and quantities specified in the Plans.

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**REVISION OF SECTION 614
COMMUNICATION CABINET**

- (e) *12 VDC Power Supply.* The 12 VDC power supply shall support an input voltage range of 85-264 VAC and frequency range of 47-63 Hz. It shall have a typical efficiency of at least 76% and typical AC current of 1.6 A at 115 VAC. The 12 VDC power supply shall provide an output voltage of 12 VDC and have a minimum current rating of 6.3 A. It shall support an output current range of 0 to 6.3 A (minimum) and have a rated power of 75 W (minimum). The 12 VDC power supply shall have overload protection of 105-150% for its rated output power and overvoltage protection for voltages of 15-16.5 VDC. It shall be designed for an operating temperature of +14°F to +140°F and humidity levels of 20% to 90% (non-condensing). The 12 VDC power supply shall conform to the following standards: IEC 60068-2-6 Environmental Testing (Vibration) and UL 508 Industrial Control Equipment. It shall be DIN rail mountable, have dimensions not exceeding 5 inches (H) × 2.25 inches (W) × 4 inches (D) and a weight of not more than 1.5 pounds. One 12 VDC power supply shall be provided with each communications cabinet.
- (f) *Fiber Optic Patch Panel.* Where communications cabinets are shown on the Plans to be connected with fiber optic cables, the Contractor shall provide one 6-port fiber optic patch panel mounted to the back panel as shown on the Plans. The panels shall have hinged doors to provide future access to both the fiber fan out and the termination bulkheads. The panel shall be sized to accommodate the entry of the lateral fiber optic cable, fiber fan out, bulkheads, and the fiber patch cable with access doors closed. The fiber optic patch panel shall be suitable for wall mounting and have dimensions not exceeding 5 inches (W) × 6 inches (L) × 2 inch (D). Each fiber optic patch panel shall include a flat polypropylene cassette, adapters, 6-fiber buffer tube fan-out kit (with 25 inch furcation tubing), strain relief boot, grommet tape, zip ties and wall mounting bracket. Terminations within the patch panel shall be for ST-UPC connectors and must be compliant with the Telcordia GR-326 Generic Requirements for Single Mode Optical Connectors and Jumper Assemblies. The manufacturer shall perform acceptance testing for insertion loss and return loss with the test certification provided with each patch panel.

Each communications cabinet shall come with a warranty. The warranty shall cover all communication cabinet materials and workmanship, including pole mounting kits, for two years after delivery of each communication cabinet.

Service Disconnect. The service disconnect shall have factory installed main lugs. It shall have an ampere rating of 70 A, a voltage rating of 120/240 VAC (3-wire, single phase) and a short circuit current rating of 10 kA. The service disconnect shall accommodate up to four single pole circuits or two tandem circuit breakers. It shall accept aluminum wire sizes of #12 AWG to #3 AWG and copper wire sizes of #14 AWG to #4 AWG. The service disconnect shall utilize a tin plated aluminum bus and include a grounding bar. It shall have been specifically designed for industrial requirements to protect electrical systems, equipment and people and must be UL listed.

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**REVISION OF SECTION 614
COMMUNICATION CABINET**

The service disconnect shall be NEMA 3R rated with the following maximum dimensions: 5 inches (W) × 9.5 inches (H) × 4 inches (D). It shall be constructed of galvanized steel with knockouts on the sides, bottom and back and a rainproof closing cap for any hub opening on the top of the enclosure. The service disconnect shall have a gray baked enamel finish electrodeposited over cleaned, phosphatized, galvanized steel. The complete service disconnect shall include the interior trim and door. The door shall open upward and be equipped with a hasp and staple for padlocking.

The Contractor shall be responsible for sizing the circuit breakers in the service disconnect in accordance with Article 240 of the NEC and circuit breakers must conform to UL 489 Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures. The Contractor shall consider all loads within the communications cabinet to be continuous except for the duplex GFCI receptacles which shall be non-continuous.

One service disconnect and corresponding circuit breakers shall be provided with each communications cabinet.

CONSTRUCTION REQUIREMENTS

Communications Cabinet. All fabricated materials and added components must be free from burrs and sharp edges. Exterior seams of the cabinet shall be continuously welded with edges ground smooth to a 0.03 inch radius. All welding shall be done with gas tungsten arc welds that comply with AWS B2.1-22-015 Standard Welding Procedure Specification for Gas Tungsten Arc Welding of Aluminum and C5.6 Recommended Practices for Gas Metal Arc Welding. All welds shall be neatly formed and free of blisters, blowholes, cracks and other irregularities.

The cabinet door opening shall be designed to prevent dust and moisture intrusion. All flange joints shall be welded or continuously formed. The door shall have an adequately sized, oil-resistant gasket that provides a uniform seal with the door frame surface and shall be permanently bonded to the door. The door shall utilize a continuous stainless steel hinge that allow for door removal from the hinge side. Hinges shall be mounted such that the cabinet door opens out to the left, unless otherwise specified on the Plans or as mandated by the Department. Hinges shall be mounted with appropriately sized stainless steel hardware. The door shall be equipped with a hasp and staple for padlocking. The Department prefers that a Corbin #2 key lock be utilized in place of the hasp and staple if the NEMA 4X rating can be maintained. A document holder constructed of high-impact thermoplastic shall be provided for each communications cabinet and permanently mounted to the lower portion of the inside door. The Contractor shall insert a copy of the communications cabinet bill of materials, individual communications cabinet component specification sheets and an asbuilt electrical/fiber optic/low-voltage wiring and cabling diagram of the communications cabinet in the document holder. Mounting holes on the back of the communications cabinet shall be installed at the factory (communications cabinet Manufacturer) to assure NEMA 4X integrity along with all factory-recommended mounting and sealing hardware for use with the pole mounting kit. Field installation or modification of mounting holes shall be prohibited.

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**REVISION OF SECTION 614
COMMUNICATION CABINET**

Two tapped conduit access holes shall be made on the bottom of the communications cabinet to provide access for electrical wiring, specific field device low-voltage control cabling, waveguides and fiber optic cabling, as applicable for each communications cabinet application. The conduit access holes shall be sized and positioned at locations shown in the Plans to ensure the proper, safe routing of cabling entering the cabinet. The holes shall be free of burrs and sharp edges prior to the installation of LFMC, fittings and nipples. Drilled and tapped conduit access holes and appropriate sealing strategies to maintain a NEMA 4X integrity shall be performed at the factory and no field installation or modification of the conduit access holes shall be permitted.

Each communications cabinet shall have tapped pads to provide for the mounting of a back panel as specified herein.

Both the power conditioner and power strip shall be mounted on the back panel. Mounting locations shall be as shown in the Plans.

Mounting of equipment and hardware onto the back panel shall be through the use of self-tapping screws or Velcro as required per the Plans. Self-tapping screws shall be of appropriate size for the equipment or hardware being installed onto the back panel. The length of the self-tapping screw shall not exceed a ½ inch and the bit recess in the screw head shall be hexagonal.

Where fiber optic communications is utilized, the Contractor shall install the lateral fiber optic cable into the communications cabinet. The buffer tube fan-out kit supplied with the fiber optic patch panel will be installed so that the six fibers in the buffer tube are inserted into the 900 µm diameter furcation tubes that are color-coded to match the fiber color scheme. ST-UPC connectors shall be installed per the requirements of the Fiber Optic Cable specifications. The connectors shall be terminated within the fiber optic patch panel with the upper connector position being #1 (blue) and the lower connector position being #6 (white). Fiber optic jumpers shall be installed between the patch panel and fiber optic communication equipment as shown in the Plans.

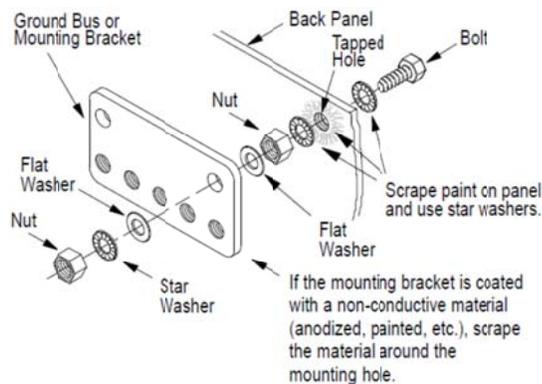
Cable management and strain relief shall be employed within the communications cabinet. Cables shall be labeled and neatly organized using cable ties and/or Velcro. Velcro shall be used on fiber optic jumper cables or bundles of cables containing fiber optic jumper cables. Unused spaces within the back panel and interior wall of the communications cabinet may be used to facilitate cable management, but installation of cable management hardware that penetrate the interior walls of the communications cabinet shall not be permitted in order to maintain NEMA 4X integrity.

The communications cabinet manufacturer shall affix a permanent label on the inside of the door that identifies the cabinet type, date of manufacture, warranty expiration date and manufacturer's name. The warranty expiration date shall be expressed in the (mm/dd/yyyy) format.

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**REVISION OF SECTION 614
COMMUNICATION CABINET**

- (a) *Grounding.* Connection to the grounding electrode system shall be provided to place the equipment, hardware, back panel and communications cabinet at earth ground potential. The Contractor shall bolt mount a ground bus to the back panel of the communications cabinet at the location shown in the Plans and depicted in Figure 1.



**Figure 1
BOLT MOUNTING OF A GROUND BUS TO BACK PANEL**

The Contractor shall make good electrical connections between the back panel and communications cabinet through the back panel mounting screws and the cabinet's grounding stud. Wherever contact is made, remove paint or other non-conductive finish from around tapped holes. The ground bus and number of tapped hole positions within the ground bus shall be sized by the Contractor as needed for each communications cabinet. Equipment grounding conductors shall be run from each powered device to the grounding bus using stranded copper wire as required per Article 250 of the NEC. DIN rails shall be connected to the ground bus using a minimum #8 AWG stranded copper wire. Figure 2 shows the ground bus connection details.

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REVISION OF SECTION 614
COMMUNICATION CABINET

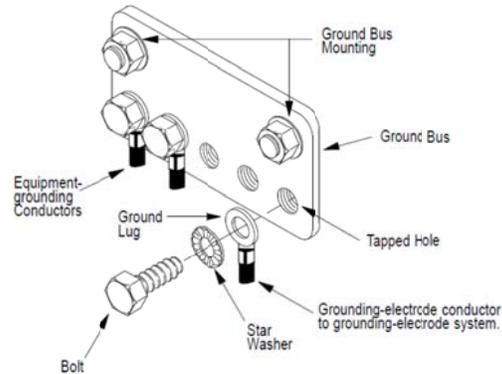


Figure 2
GROUND BUS CONNECTION DETAILS

Service Disconnect. Each service disconnect shall be readily accessible and installed on the pole as shown in the Plans so that the center of the grip of the operating handle of the circuit breaker, when in its highest position, is not more than 6 feet 7 inches above the ground or as required per Article 240.24 of the NEC.

The neutral from the power source or service enclosure shall be connected to the ground bar in the service disconnect. The ground bar shall be connected to the service disconnect using a bonding strap. The ground bar shall be connected to a grounding electrode using grounding conductors conforming to the requirements of Article 250.122 of the NEC. The grounding electrode shall conform to the requirements of Articles 250.52 through 250.70 of the NEC.

METHOD OF MEASUREMENT

Communications cabinets shall be measured by the actual number of units installed and accepted, and full compensation shall include all document holders, pole mounting kits, back panels, factory installed mounting and conduit access holes, LFMC conduit, conduit fittings, outlet boxes, receptacles, power conditioners with power strips, DIN rails, 12 VDC power supplies, fiber optic patch panels, mounting and sealing hardware, grounding system, service disconnect and warranties as described herein, including all labor, low voltage cabling, fiber optic cable jumpers, electrical wiring, materials, tools, equipment and incidentals required to perform the work. Number of each type of communications cabinet shall be as listed in the project tabulations.

**REVISION OF SECTION 614
FIBER OPTIC CABLE (Single Mode)**

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing single mode fiber optic cable.

Fiber optic cable shall be used for either main backbone cable or lateral cables that connect to equipment field cabinets. The main backbone cable shall be terminated in a Communications Node or Regeneration Building. Lateral fiber cables shall be terminated using fan-out kits in a termination patch panel in the field equipment cabinet.

All fiber optic cables shall be suitable for outdoor conduit installation.

MATERIALS

All fiber optic cable shall have compatible chromaticistics with proposed and existing cables.

All optical cables furnished on this project shall meet the following fiber optic industry standards:

1. International Telecommunications Union Recommendation G.652 Table D
2. Electronic Industries Alliance (EIA) Telecommunications Industry Association (TIA)
3. International Organization for Standardization (ISO)
4. Telecommunication industry Association (TIA)
5. International Telecommunications Union (ITU)
6. Insulated Cable Engineers Association (ICEA)

All cables shall be new and unused non-armored outdoor cable consisting of dispersion-unshifted, low water peak single-mode fiber strands free of surface imperfections and inclusions. Each single mode fiber shall consist of a doped silica core surrounded by a concentric silica cladding. The fiber shall be of matched clad design.

Fiber Strands

- (1) Typical core diameter of 8.3 μ m
- (2) Cladding Diameter of 125.0 \pm 1 μ m
- (3) Core-to-Cladding Offset: \leq 0.5 μ m
- (4) Cladding Non-Circularity: \leq 1 %
- (5) Coating Diameter (Colored): 245 \pm 10 μ m.
- (6) Maximum Attenuation (Loose Tube): 0.35 dB/km at 1310 nm wavelength and 0.22 dB/km at 1550 nm wavelength
- (7) Mode-Field Diameter: 9.20 \pm 0.30 μ m at 1310 nm wavelength and 10.40 \pm 0.50 μ m at 1550 nm wavelength
- (8) Attenuation at the Water Peak: 0.32 to 0.34 dB/km at 1383 \pm 3 nm wavelength
- (9) Cutoff Wavelength: 1260 nm.
- (10) Zero Dispersion Wavelength: 1300nm to 1322 nm
- (11) Zero Dispersion Slope: 0.090 ps / (nm² • km)
- (12) Polarization Mode Dispersion: 0.06 ps/ $\sqrt{\text{km}}$
- (13) Maximum Polarization Mode Dispersion at 0.01% distribution (PMDq): 0.20 ps/ $\sqrt{\text{km}}$

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REVISION OF SECTION 614
FIBER OPTIC CABLE (Single Mode)

- (14) Maximum Fiber Dispersion: 3.5 ps/(nm • km) for 1285 nm through 1330 nm and shall be < 18 ps/(nm • km) at 1550 nm.
- (15) Fiber Curl: ≥ 4.0 m

All optical fibers shall be proof tested by the manufacturer to a minimum load of 0.7 GN/m² (100 ksi).

The fibers shall not adhere to the inside of the buffer tube.

The coating shall be a dual layered, UV cured acrylate applied by the fiber manufacturer. The coating shall be capable of being mechanically stripped with a force of 0.3 – 2.0 lbf (1.3 – 8.0 N).

Each single mode fiber strand shall be color coded with distinct and recognizable colors in accordance with the most recent version of EIA/TIA-598, Optical Fiber Cable Color, as shown in the plans.

Buffer Tubes

Each buffer tube shall contain 6 or 12 fibers as appropriate for the respective size cable.

Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be 3.0 mm

Each buffer tube shall be color coded with distinct and recognizable colors in accordance with the most recent version of EIA/TIA-598, Optical Fiber Cable Color, as shown in the plans.

In buffer tubes containing multiple fibers, the coloring shall be stable during temperature cycling as stated under “Fiber Specification Parameters” and shall not be subjected to fading or smearing onto each other or into the buffer tube gel filling material. Colorings shall not cause fibers to stick together.

Buffer tubes shall be of a dual-layer construction with the inner layer made of polycarbonate and the outer layer made of polyester.

Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.

Buffer tubes shall be stranded around a central member of the cable using a reverse oscillation stranding process.

The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrink requirements of EIA/TIA standards.

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**REVISION OF SECTION 614
FIBER OPTIC CABLE (Single Mode)**

Fiber Cable

Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.

The central anti-buckling member of the cable shall consist of a glass reinforced plastic rod. The purpose of the central member shall be to prevent buckling.

For single layer cables, a water blocking tape shall be applied longitudinally around the outside of the strand tubes/fillers. The tape shall be held in place by a single polyester binder yarn. The water blocking tape shall be non-nutritive to fungus, electrically non-conductive homogenous. It shall also be free from dirt and foreign matter. Gel filled water-blocking compound shall not be allowed in the cable core interstices in either the backbone cable or the lateral cables.

Binders shall be applied with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking (or rendered so by the flooding compound), and dielectric with low shrinkage.

The cable shall contain at least one ripcord under the sheath for easy sheath removal.

Tensile strength shall be provided by high tensile strength dielectric yarns and shall be helically stranded evenly around the cable core.

Outer cable jacket shall have a consistent thickness throughout the entire cable length and shall be sheathed with medium density polyethylene, (MDPE). The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking tape. The MDPE shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

The cable jacket shall be free of holes, splits and blisters.

Cable jackets shall be marked with sequential foot markings, year of manufacture and a telecommunication handset symbol, as required by Section 350G of the National Electrical Safety Code (NESC). The actual length of the cable shall be within 0 to 1% of the length markings. The marking shall be in contrasting color to the cable jacket. The height of the marking shall be easily readable.

Environmental Parameters

- a) Shipping, storage and operating temperature range of the cable as defined by Bellcore GR-12 shall be;
-40°C to +75°C (-40°F to +167°F)
- b) Operating temperature range of the cable as defined by Bellcore GR-12 shall be; -40°C to +70°C (-40°F to 158°F)
- c) Installation temperature range of the cable as defined by Bellcore GR-12 shall be; -30°C to +60°C (-22°F to +140°F)

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**REVISION OF SECTION 614
FIBER OPTIC CABLE (Single Mode)**

Quality Assurance

- a) All optical fibers shall be 100% attenuation tested. The attenuation of each fiber shall be provided with each cable reel.
- b) The cable manufacturer shall be ISO 9001 registered.

Packaging

- a) The complete cable shall be packaged for shipment on non-returnable wooden reels.
- b) Top and bottom ends of the cable shall be available for testing.
- c) Both ends of the cable shall be sealed to prevent the ingress of moisture.
- d) Each reel shall have a weatherproof reel tag attached identifying the reel and cable.
- e) Each cable shall be accompanied by a cable data sheet that contains significant information on the cable.

CONSTRUCTION REQUIREMENTS

The Contractor shall provide the Engineer with two copies of the cable manufacturer's installation instructions for all fiber optic cable. All installations shall be in accordance with the manufacturer's recommendations except as otherwise directed by the Engineer. All additional costs including fiber optic cable associated to damages caused by the Contractor's neglect of recommended procedures shall be the Contractor's responsibility.

The Contractor shall submit a Method Statement to the Engineer indicating cable routing, splice points and cable end splicing locations. Installation of the cable will not be permitted until the schematic diagram has been approved by the Engineer.

Fiber optic cable including both backbone cables and lateral cables shall be installed in continuous runs. Under no conditions shall fiber optic cable be cut or spliced at intermediate points without express written direction from the Engineer.

Blowing cable is an acceptable alternative to pulling cable. If the Contractor chooses to use this method, submittals for cable installation shall be submitted along with complete information on fiber installation equipment.

The maximum pulling tension shall be 2700 N (600 lbs) during installation (short term) and 890 N (200 lbs) long term installed.

All cables shall have a minimum bending radius based on the diameter of the cable and shall meet the following:

- a) Pulled under tension, (Short Term) – 20 (Twenty times the cable diameter)
- b) Pulled not under tension, (Long Term) – 10 (Ten times the cable diameter)

The fiber optic cable shall be installed in the conduit with a split-mesh cable grip to provide a firm hold on the exterior covering of the cable.

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**REVISION OF SECTION 614
FIBER OPTIC CABLE (Single Mode)**

The manufacturer's recommended limits for cable pull lengths shall not be exceeded. The Contractor shall use a pulley system with a numerical readout indicating the cable tension. The pulley system shall be capable of alerting the installer when the cable pulling tension approaches the manufacturer's maximum allowable tension. The Contractor may supplement this procedure with a breakaway tension limiter set below the lowest recommended tensile limit of the cables being pulled. Intermediate pulleys shall be used at all pull boxes or manholes along the installation run to prevent cable damage.

If cable installation limits are met and the entire length cannot be installed completely from the shipping reel, installation shall be continued from the mid-point of the run. The Contractor shall first pull one-half of the cable from the reel at the mid-point through the conduit to one end of the run. The other half of the cable shall be removed from the reel and carefully placed on the ground in a figure eight pattern with a minimum loop diameter of 10 feet. While installing the remaining cable, care shall be taken to avoid any dragging against the ground resulting in damage or excess bending of the cable. The Contractor shall not kink, twist or bend the cable during installation coiling or uncoiling.

The cable shall be continuously lubricated as it enters the conduit. The Contractor shall only use pulling lubricants recommended by the cable manufacturer. Liquid detergent shall not be used.

If the Contractor must install new cable in conduits which contain existing fiber or electrical wiring, the Contractor shall be responsible for any damage to the existing cables or wires. After this installation the Contractor shall perform a functional test of all the equipment connected by the existing fiber cables or electrical wiring to ensure proper working conditions.

If an existing fiber optic cable is damaged during construction, it shall be removed from both points of termination and replaced, at no cost to the project. In no case shall the fill of any new conduit exceed the requirements of the National Electrical Code. The Contractor shall provide documentation to the Engineer supporting the conduit fill. All costs associated with equipment testing and repairs shall be included in the cost of the Fiber Optic Cable.

Lateral cables shall be installed in continuous runs from the backbone splice location to the field equipment cabinet. Odd length cables and reel ends are acceptable for lateral cables provided they are pre-tested and free of defects and are of sufficient lengths to archive continuous runs.

Lateral cables shall have slack and include a maximum of three locations of appropriate strain relief within all field equipment cabinets.

All fiber optic cables shall include identification labels attached to the cable in each pull box, manhole or field equipment cabinet. The label shall be provided with information as shown on the Project Detail Sheet.

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**REVISION OF SECTION 614
FIBER OPTIC CABLE (Single Mode)**

The Contractor shall splice fiber cables at locations shown on the plans. All splices shall be enclosed within a splice closure as approved by the Engineer. Following successful splicing, the splice closure shall be placed inside the pull box or manhole. The Contractor shall use tools and hardware recommended by the cable manufacturer.

Only proposed active (lit) fibers shall be spliced in the closure and terminated in the field communications cabinet. All unused (dark) fibers of both the backbone and lateral cables shall remain uncut and be neatly coiled in the splice tray within the closure. All unused buffer tubes shall remain uncut and neatly coiled along with the buffer tubes used for splicing in appropriate location in the splice closure.

Backbone and lateral buffer tubes and fiber strands shall be labeled on the splice tray prior to sealing of the closure as shown on the Project Detail Sheet. The Contractor shall coil 100 feet of backbone cable in the manholes. The Contractor shall coil 50 feet of backbone cable in pull boxes.

The Contractor shall coil 50 feet of lateral cable in the manholes. The Contractor shall coil 25 feet of Lateral cable in pull boxes.

The Contractor shall ensure that all cable coils and splice canisters are attached to the cable management hardware in all pull boxes and manholes.

The Contractor shall terminate the lateral cable at the field equipment cabinet using a buffer tube fan-out kit. Fanned-out fiber strands shall be terminated in a termination block with ST connectors.

The Contractor shall submit a final documentation package. The final documentation package shall include the cable manufacturer's installation procedures, technical support documentation and material documentation. These documents shall match the original submittals provided to the Engineer.

METHOD OF MEASUREMENT

Fiber Optic Cable shall be measured by the Linear Foot for both backbone and lateral cable and shall include all labor and materials required to install, splice and terminate the cable to make a complete and operational system and shall include the following items:

1. All required splicing, splice closures, splice kits, hardware, splicing tools and labor to accomplish the splices.
2. All required termination panels in field equipment cabinets.
3. All required fan-out kits, hardware and labor to accomplish fan-out.
4. All required termination connectors, adapters, jumpers, pigtails, hardware and labor required to accomplish lateral cable terminations.
5. Identification labels for both backbone and lateral fiber cables in each pull box, manhole and field equipment cabinet.
6. As Built Documentation

**REVISION OF SECTION 614
FIBER OPTIC CABLE AS-BUILT DOCUMENTATION**

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

The Contractor shall complete and forward to the Project Engineer the Fiber Cable As-Built Documentation Sheet as part of their final submittals on the project. This form is an aide to document information as it pertains to the installation of fiber optic cable along the project corridors as part of this project.

At each pull box and manhole location, fiber optic cable information to be provided shall include the following:

- 1) Cable sequential foot marking measurements stamped on the cable jacket as the cable enters and exits the pull box
- 2) Type of splices, lateral cables or cable end splices
- 3) Number of lateral cables at the pull box location
- 4) Fiber cable ID serial number
- 5) Identification or location of pull boxes or manholes as they are shown on the final as-built documentation

As part of the as-built documentation, any revised fiber optic splices shall also be provided as marked up copies of the original splice diagrams. If changes are made during the splicing procedures, those changes shall be documented by the Contractor and submitted to the Project Engineer as final as-built drawings.

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REVISION OF SECTION 614
FIBER OPTIC CABLE AS-BUILT DOCUMENTATION
FIBER OPTIC CABLE AS-INSTALLED DOCUMENTATION SHEET

TO NEXT PULL BOX or
MANHOLE

CABLE MEASUREMENT OUT _____

PULL BOX LOCATION _____
MANHOLE NUMBER _____

CABLE ID NUMBER _____

CABLE MEASUREMENT IN _____

SPLICE POINT YES ___ NO ___
CABLE END SPLICE YES ___ NO ___
NUMBER OF LATERAL CABLES _____

CABLE MEASUREMENT OUT _____

PULL BOX LOCATION _____
MANHOLE NUMBER _____

CABLE ID NUMBER _____

CABLE MEASUREMENT IN _____

SPLICE POINT YES ___ NO ___
CABLE END SPLICE YES ___ NO ___
NUMBER OF LATERAL CABLES _____

CABLE MEASUREMENT OUT _____

PULL BOX LOCATION _____
MANHOLE NUMBER _____

CABLE ID NUMBER _____

CABLE MEASUREMENT IN _____

SPLICE POINT YES ___ NO ___
CABLE END SPLICE YES ___ NO ___
NUMBER OF LATERAL CABLES _____

FROM PREVIOUS PULL BOX or
MANHOLE

**REVISION OF SECTION 614
FIBER OPTIC CABLE INSTALLATION**

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Fiber optic cable installed on this project will be installed in electrical conduits, pull boxes and equipment communication cabinets which contain existing electrical cable or electronic equipment currently carrying communications data from existing intersection traffic signals and roadway devices. The new fiber cable shall be installed in a manner which will not interfere with the integrity of the existing cable and or equipment. Slack fiber cable shall be coiled in pull boxes, manholes and communications cabinets using proper fiber management as noted on the plans. Fiber optic cable installed in traffic controller cabinets shall be placed in a manner which will not interfere with the maintenance or the traffic signal cable, wiring or equipment. All OTDR testing shall be conducted as stated in this specification and in accordance with the Project Special Provision, Test Fiber Optic Cable, included in this plan set.

The Contractor shall install all fiber optic cables in accordance with the splicing diagrams as shown in the plans. The Contractor shall conduct an on-reel test prior to installing any fiber cables. After the on-reel test the Contractor shall provide the Project Engineer with all resultant documentation prior to actual cable installation. No installation shall commence until the Project Engineer reviews and accepts all test results showing all fibers in the cables are undamaged, containing no breaks or micro bends. Once the results are accepted, the fiber cable may be installed. If the test results show damage to any strand or strands within a reel, that reel shall be rejected, replaced and retested at no additional cost to the project.

Once the fiber cable is accepted by the Project Engineer, the cable may be installed. The fiber cable is to be installed in reel lengths that minimize cable end splices, in turn minimizing fiber cable loss. Once the entire cable is installed and all cable end splices are complete, bi-directional testing shall be conducted to assure that no damage occurred in the installation process.

For backbone fiber cable, if any strand(s) of the fiber cables show damage from the Contractor's installation, that entire section of fiber cable shall be removed, re-installed and re-spliced from the cable end splice point at no additional cost to the project.

For lateral fiber cable, if any strand (s) of the fiber cables show damage from the Contractor's installation, the entire length of fiber cable shall be removed, re-installed and re-splices form the splice point to the device communication cabinet at no additional cost to the project.

Prior to any fiber optic work, the Contractor shall give the Project Engineer a detailed installation and splicing schedule a minimum of one week, prior to commencing work. All installation, splicing, termination, and testing shall be listed on the schedule and any revisions to this schedule shall be re-submitted to the Project Engineer as soon as the changes are made.

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REVISION OF SECTION 614
FIBER OPTIC CABLE INSTALLATION

After completing all splicing and termination work, a final inspection of the fiber network will be conducted. If damage exists to the fiber optic cable system due to Contractor negligence, all costs associated with the cable, pulling of the cable, splicing, splice canisters and testing of the network shall be at the Contractor's expense.

**REVISION OF SECTION 614
FIBER OPTIC PRE-CONNECTORIZED CABLE**

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of the installation of fiber optic pre-connectorized patch cables in traffic signal cabinets, ramp metering cabinets and automated traffic recorder station cabinets for connection of optical devices from the termination panel to the optical device. Patch cables for these devices shall also be installed in the Colorado Transportation Management Center.

At the Ethernet Router locations, course wavelength division multiplexor (CWDM) shall be used and shall require bend intensive fiber optic pre-connectorized patch cables. Bend intensive (optimized) pre-connectorized patch cable shall also be required for CWDM optical connections at the Colorado Transportation Management Center. Ethernet Router location

MATERIALS

The pre-connectorized cables for traffic signal cabinets, ramp metering cabinets and automated traffic recorder stations shall be jacketed for extra protection and shall be provided with pre-connectorized connectors on both ends to match the optical connectors to which they connect. Connectors shall be pre-terminated by the manufacturer with a convex physical contact (PC) polish on the ferrule end to reduce reflection.

The measured attenuation of the connector (inclusive of coupler and mated test connector) shall not exceed an average of 0.3 dB for all connectors provided. Any connector found in excess of 0.5 dB shall be rejected. Reflectance shall be less than -40 dB from 14° F to 140° F (-10°C to +60°C). The manufacturer shall have a program that periodically tests connectors to ensure than after 1000 re-matings, the attenuation will not change more than 0.2 dB.

The connector shall be able to withstand an axial pull of 25 lbs. with no physical damage to the connector and no permanent optical degradation more than 0.3 dB.

The pre-connectorized cables for CWDM optics modules shall be jacketed for extra protection and shall be provided with pre-connectorized connectors on both ends to match the optical connectors to which they connect. Connectors shall be pre-terminated by the manufacturer. Duplex patch cables shall be installed in all field cabinets for connection from the patch panel to the CWDM optic. In the Colorado Transportation Management Center Data Center, simplex patch cables shall be installed for connection from the 8-Channel Course Wavelength Division Multiplexing LGX Module port to the CISCO Ethernet Router optics. The bend intensive (optimized) cable shall be used to enable tight bend radii and routing to help alleviate data loss.

Single mode fiber optic cables for installation in field cabinets shall be made with bend insensitive fiber satisfying International Telecommunication Union (ITU) G.657 category A1 recommendations. The cable shall have a 'tactical' polyurethane jacket to resist bending.

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**REVISION OF SECTION 614
FIBER OPTIC PRE-CONNECTORIZED CABLE**

The bend intensive (optimized) patch cable shall have the following requirements for simplex cables:

- Yellow PVC Jacket Material
- Nominal Dimension: 2.95 mm
- Weight: 16 Lbs./KM
- Pull Load (N): 1332 (Install) / 1066 (Operate)
- Bend Radius: 10mm (1 Turn)
- Core Size: 9/125
- Attenuation: 0.50 dB/Km at 1550nm (Maximun)
- Link Lengths at 1550nm: 10,000 Mtr (For 1GB/s) – 5,000 Mtr (For 10 GB/s)

The bend intensive (optimized) patch cable shall have the following requirements for duplex cables:

- Yellow PVC Jacket Material
- Noninal Dimension: 2.95 mm x 5.8 mm
- Weight: 32 Lbs./KM
- Pull Load (N): 2664 (Install) / 2132 (Operate)
- Bend Radius: 10mm (1 Turn)
- Core Size: 9/125
- Attenuation: 0.50 dB/Km at 1550nm (Maximun)
- Link Lengths at 1550nm: 10,000 Mtr (For 1GB/s) – 5,000 Mtr (For 10 GB/s)

The bend intensive (optimized) pre-connectorized patch cable shall meet the following specifications:

Patch Cable Connectors

EIA, TIA-55 (FOCIS)
UL94 V-O
GR-326, Issue 3 Specifications

Cable

Telcordia GR-409

All connectors shall have ceramic ferrules.

The cables shall contain the exact number of loose tube fibers and connectors to connect the optical equipment. If the optical equipment transmits and receives data on a single fiber, the pre-connectorized cable shall contain only a single fiber, (simplex). When the optical device transmits and received data on two or four fibers, a pre-connectorized cable shall be provided with 2 (two) fibers per cable, (duplex), for each bulkhead pair, (transmit and receive).

Single mode fiber optic cables for installation in field cabinets shall be made with bend insensitive fiber satisfying International Telecommunication Union (ITU) G.657 category A1 recommendations. The cable shall have a 'tactical' polyurethane jacket to resist bending.

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**REVISION OF SECTION 614
FIBER OPTIC PRE-CONNECTORIZED CABLE**

CONSTRUCTION REQUIREMENTS

Connectors shall be compatible with both the connectors on the optical devices and the termination patch panel bulkhead panels.

At the CTMC, the pre-connectorized cables shall be installed in the cable management hardware in the equipment racks. The Contractor shall provide patch cables of sufficient length to span from the fiber patch panel to the optical network device. This length shall include a maximum of 4 feet of slack cable. Appropriate cable management shall be used while installing cables.

Prior to installation, all pre-connectorized cable bulkhead connectors shall be cleaned with lint-free fiber wipes moistened with Isopropyl Alcohol 99% U.S.P. After cleaning with alcohol, the bulkhead shall be cleaned with an optical connector cleaner to ensure the all residue is removed from the bulkhead surface.

Any manufacturer testing reports showing db loss for both Side A and Side B of the pre-connectorized cables shall be submitted as part of the as-built documentation. Installation location shall be noted on the test report for future reference.

At the CTMC cables shall have identification labels at each end indicating patch panel number, field device and field device location.

At all field device locations, each cable shall have individual labels indicating the devices, lateral fiber color and the data transmitting description, (example: Tx or Rx).

Patch cable labeling shall be as shown on the Project Detail Sheet.

The pre-connectorized cables shall be provided in the following lengths.

Field Device Cabinets.....	3 Feet – 0 Inch maximum
CTMC	Cable shall be of sufficient length to accommodate connection of each individual optical device to the equipment rack termination panel while allowing for appropriate slack.

METHOD OF MEASUREMENT

Fiber optic pre-connectorized cables and labeling will not be measured or paid for separately but will be considered subsidiary to the individual optical device item and shall include all labor, materials and equipment required to complete the work. Also included shall be all information labeling in the field device cabinet termination panels.

**REVISION OF SECTION 614
FIBER OPTIC TERMINATION PANEL**

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing fiber optic termination panels in Intelligent Transportation System (ITS) device communication cabinets, traffic signal controller cabinets, ramp metering controller cabinets and automated traffic recorder station cabinets for single mode fiber.

MATERIALS

The units shall meet the design requirements of ANSI/TIA/EIA-568 and the plastics flammability requirements of UL 94 V-0.

Termination panels shall be manufactured using 16-gauge aluminum or equivalent and shall be finished with powder coat for durability. The termination panel shall have a slide out interior for future access of the remaining lateral fibers and the back side of the bulkheads while minimizing disturbance to existing fiber and terminations.

Termination panels for ITS communication cabinets shall be a single six (6) port panel with ST type bulkheads. The panels shall have hinged doors to provide future access to both the fiber fan out and the termination bulkheads. The panel shall be sized to accommodate the entry of the lateral fiber optic cable, fiber fan out, bulkheads, and the fiber patch cable with access doors closed. The fiber optic patch panel shall be suitable for wall mounting and have dimensions not exceeding 5 inches (W) × 6 inches (L) × 2 inch (D). Each fiber optic patch panel shall include a flat polypropylene cassette, adapters, 6-fiber buffer tube fan-out kit (with 25 inch furcation tubing), strain relief boot, grommet tape, zip ties and wall mounting bracket. Terminations within the patch panel shall be for ST-UPC connectors and must be compliant with the Telcordia GR-326 Generic Requirements for Single Mode Optical Connectors and Jumper Assemblies. The manufacturer shall perform acceptance testing for insertion loss and return loss with the test certification provided with each patch panel.

Termination panels for traffic signal controller cabinets, ramp metering controller cabinets and automated traffic recorder station cabinets shall be sized to accommodate twenty four (24) ports and mounted in the cabinets' 19-inch rack rails. The panels shall be provided with two (2) ST termination bulkhead 6 pack modules for fiber terminations as shown in the plans. The panel shall be provided with covers for the remaining spaces for future bulkhead installations. All bulkheads shall be metal. Plastic bulkheads will not be accepted.

CONSTRUCTION REQUIREMENTS

Termination panels within cabinets shall be mounted in locations which will allow for ease of access and shall not interfere with maintenance of the internal equipment.

The Contractor shall use proper strain relief inside the termination panel for the fiber cable and fiber fan out strands per the manufacturer's recommendations. The use of tape to secure the individual fanned out strands to the bottom of the termination panel shall not be allowed.

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**REVISION OF SECTION 614
FIBER OPTIC TERMINATION PANEL**

All hardware shall be installed in accordance with manufacturer's recommendations. All termination panels shall have a labeling scheme that complies with ANSI/TIA/EIA-606 and the details as shown on the Project Details Sheet.

METHOD OF MEASUREMENT

Fiber Optic Termination Panels will not be measured or paid for separately ~~but will be considered subsidiary to the Fiber Optic Cable (Single Mode) pay item.~~

Fiber Optic Termination Panels shall include all bulkheads, covers for empty spaces, labeling panels and all materials, hardware, labor and equipment necessary to complete the work.

**REVISION OF SECTION 614
TEST FIBER OPTIC CABLE**

Section 614 of the Standard specifications is hereby revised for this project as follows:

Subsection 614.01 shall include the following:

Test fiber optic cable shall include an OTDR on reel test and on all fiber optic cable strands install on the project by the Contractor. In addition, an optical power meter test shall be conducted on fiber strands from all device locations to the regeneration node buildings.

Contractor shall use the Optical Spectrum Analyzer purchased as part of this project to test all course wavelength division multiplexing wavelengths (CWDM). Testing shall be conducted for all CWDM optics at the Colorado Transportation Management Center (CTMC) to individual field Ethernet field Routeres and from the field Routeres to the CTMC. This testing shall commence after all fiber optic cable is tested as stated in this specification.

Bidirectional wavelengths shall be tested at all optics to ensure the proper wavelength is being dropped at the Ethernet Routeres and in turn sent to the CTMC.

As part of the CWDM design all wavelengths will travel on single fibers, and dropped to individual Ethernet Routeres in the field. Tests shall b required at all Router locations to ensure the proper wavelength is delivered and transmitted.

If required, CTMC personnel will aid in this testing.

Subsection 614.08 shall include the following:

(r) Test Fiber Optic Cable. For this project this work shall consist of the testing of either multimode or Single Mode fiber optic cable as shown and tabulated in the plans. The testing procedures involve an OTDR test and an Optical Power Meter Test.

Guidelines for fiber optic cable testing include:

- (1) Test jumpers and patch cords must be of the same fiber core size and connector type as the cable system:
Multimode fiber 62.5/125 μm
Single Mode fiber 8.3/125 μm
- (2) The light source and OTDR must operate within the range of 850 \pm 30 nm or 1300 \pm 20 nm for multimode testing in accordance with ANSI/EIA/TIA-526-14.
- (3) The light source and OTDR must operate with the range of 1310 \pm 10 nm or 1550 \pm 20 nm for Single Mode testing in accordance with ANSI/EIA/TIA-526-7.
- (4) The power meter and the light source must be set to the same wavelength during testing.

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**REVISION OF SECTION 614
TEST FIBER OPTIC CABLE**

- (5) The power meter must be calibrated and traceable to the National Institute of Standards and Technology (NIST).
- (6) All system connectors, adapters and jumpers must be cleaned as per manufacturer's instructions before measurements are taken.

A) Fiber Optic Cable Testing Equipment. The following is required to perform fiber optic cable tests:

- (1) An OTDR
- (2) A test reel, if necessary
- (3) A light source at the appropriate wavelength
- (4) Optical Power Measurement Equipment
- (5) Test Jumpers as specified below

Multimode Fiber Testing

CPR Test Jumper-1 shall be 1-5 meters long with connectors compatible with the light source and power meter and have the same fiber construction as the link segment being tested.

CPR Test Jumper-2 shall be 1-5 meters long with connectors compatible with the light source and power meter. Test Jumper-2 shall contain Class IV a single-mode fiber for tests on 1300 nm light sources and from which is single-moded at 850 μm for tests on 850 nm light sources.

Single Mode Fiber Testing

CPR Test Jumper-1 and Test Jumper-2 shall be 1-5 meters long with connectors compatible with the light source and power meter and have the same fiber construction as the link segment being tested.

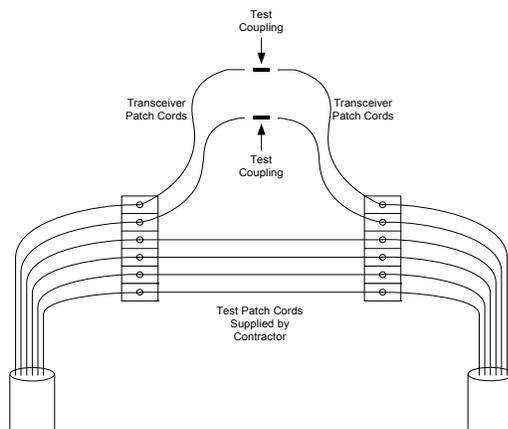
B) Optical Fiber Cable Testing with OTDR. The Contractor shall perform an OTDR test of all fibers in all tubes on the reel prior to installation of the fiber. The test results shall be supplied to the Engineer prior to installation of the cable.

If the fiber is specified as "Install Only", the Contractor shall test the fiber on the reel and provide the test results to the Engineer prior to accepting the cable. After installation, if there are unused portions of cable remaining on the reel, the Engineer may request the Contractor or other qualified technician to perform a reel test. The Contractor shall provide the Engineer the test results prior to delivering the cable to the Engineer. Any cable damaged while in the Contractor's possession shall be replaced at the Contractor's expense.

All fiber testing shall be performed on all fibers in the completed end-to-end system. Testing shall consist of a bi-directional end-to-end OTDR trace performed per TIA/EIA-455-61. The system margin loss measurements shall be provided at 850 and 1300 nm for multimode fibers and 1310 and 1550 for Single Mode fibers. If the Plans require installation of a fiber optic patch panel, the Contractor shall supply patch cords to patch all terminated fibers

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REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

through the panel for all fiber testing. If patch cords are specified in the Plans for final equipment installation, these patch cords shall be connected using a test coupling for the end-to-end test.



OTDR readings will be used to ensure proper installation and to troubleshoot faults. OTDR signature traces will be used for documentation and maintenance. An OTDR provides an indirect estimate of the loss of the cable plant, generally, more accurate or reliable values will be obtained by using an Optical Power Meter. For fibers that are identified in the Plans to be left unterminated, an OTDR shall be used to test end-to-end attenuation.

Loss numbers for the installed link shall be calculated by taking the sum of the bi-directional measurements and dividing that sum by two.

The Contractor shall use an OTDR that is capable of storing traces electronically and shall save each final trace.

To ensure the traces identify the end points of the fiber under test and the fiber designation, the Contractor shall use a test reel, if required, to eliminate the “dead zone” at the start of the trace so that the start of the fiber under test can be identified on the trace. Indicate the length of the test reel for all test results.

If the fiber designation is not indicated on the trace itself, the Contractor shall provide a cross-reference table between the stored trace file name and the fiber designation.

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**REVISION OF SECTION 614
TEST FIBER OPTIC CABLE**

In compliance with EIA/TIA-455-61 “Measurement of Fiber or Cable Attenuation Using an OTDR” the Contractor shall record the following information during the test procedure:

- (1) Names of personnel conducting the test.
- (2) Type of test equipment used (manufacturer, model, serial number, calibration date).
- (3) Date test is being performed.
- (4) Optical source wavelength and spectral width.
- (5) Fiber identification.
- (6) End point locations.
- (7) Launch conditions
- (8) Method of calculation for the attenuation or attenuation coefficient.
- (9) Acceptable link attenuation.

C) Optic Fiber Cable Testing with Optical Power Meter. The Contractor shall conduct an Optical Power Meter Test for each fiber installed.

Multimode segments shall be tested in one direction at both the 850 nm and the 1300 nm wavelength.

Single Mode segments shall be tested in one direction at both the 1310 nm and 1550 nm wavelength.

In compliance with TIA/EIA-526-14A “Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant” and TIA/EIA-526-7 “Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant,” the following information shall be recorded during the test procedure:

- (1) Names of personnel conducting the test.
- (2) Type of test equipment used (manufacturer, model, serial number, calibration date).
- (3) Date test is being performed.
- (4) Optical source wavelength, spectral width, and for multimode, the coupled power ratio (CPR).
- (5) Fiber identification.
- (6) End point locations.
- (7) Test direction.
- (8) Reference power measurement (when not using a power meter with a Relative Power Measurement Mode).
- (9) Measured attenuation of the link segment.
 - (19) Acceptable link attenuation.

The minor attenuation differences due to test direction are on par with the accuracy and repeatability of the test method. Lateral segments within a building are limited to 90 meters. Therefore, attenuation differences caused by wavelength are insignificant, and as a result, single wavelength testing is sufficient.

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REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

D) Acceptable Attenuation Values. Acceptable attenuation values shall be calculated for each fiber tested. These values represent the maximum acceptable test values.

- 1) Multimode Fiber. The general attenuation equation for any multimode link segment is as follows:

$$\text{Acceptable Link Attn.} = \text{Cable Attn.} + \text{Connection Attn.} + \text{Splice Attn.} + \text{CPR Adj.}$$

62.5 μm Multi-mode Attenuation Coefficients:

- Cable Attn. = Cable Length (km) x (3.40 dB/km@850 nm or 1.00 dB/km@1300 nm)
- Connection Attn. (ST or SC connectors) = (No. of Connections x 0.39 dB) + 0.42 dB.
- Connection Attn. (LC connectors) = (No. of Connections x 0.14 dB) + 0.24 dB.
- Splice Attn. (Mechanical or Fusion) = Splices x 0.30 dB.
- CPR Adj. = See table below.

A connection is defined as the joint made by mating two fibers terminated with re-mateable connectors (e.g. ST, SC, LC).

Multi-mode Light Source CPR Adjustment					
	Cat. 1 Overfilled	Cat. 2	Cat. 3	Cat. 4	Cat. 5 Underfilled
Links with ST or SC Connections	+0.50	0.00	-0.25	-0.50	-0.75
Links with LC Connections	+0.25	0.00	-0.10	-0.20	-0.30

The Coupled Power Ratio of a light source is a measure of the modal power distribution launched into a multimode fiber. A light source that launches a higher percentage of its power into the higher order modes of a multimode fiber produces a more over-filled condition and is classified as a lower category than a light source that launches more of its power into just the lower order modes producing an under-filled condition. Under-filled conditions result in lower link attenuation, while over-filled conditions produce higher attenuation. Therefore, adjusting the acceptable link attenuation equation to compensate for a light source's launch characteristics increases the accuracy of the test procedure.

- 2) Singlemode Fiber. The general attenuation equation for any Single Mode link segment is as follows:

$$\text{Acceptable Link Attn.} = \text{Cable Attn.} + \text{Connector Attn.} + \text{Splice Attn.}$$

8.3 μm Single-mode Attenuation Coefficients:

- Cable Attn. = Cable Length (km) x (0.34 dB/km@1310 nm or 0.25 dB/km@1550 nm)
- Connection Attn. (ST or SC connectors) = (No. of Connections x 0.39 dB) + 0.42 dB.
- Connection Attn. (LC connectors) = (No. of Connections x 0.14 dB) + 0.24 dB.

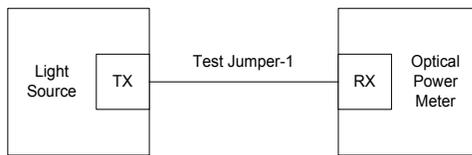
-6-
**REVISION OF SECTION 614
TEST FIBER OPTIC CABLE**

Splice Attn. (Mechanical or Fusion)=Splices x 0.30 dB.

E) Test Procedures. All fiber testing shall be performed on all fibers in the completed end-to-end system.

(1) Multimode Fiber. The multimode fiber cable test shall be conducted as follows:

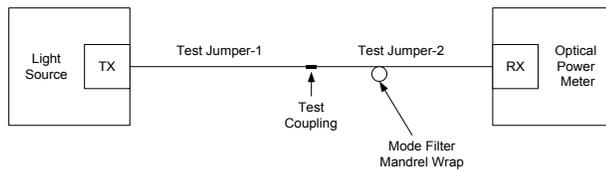
Clean the test jumper connectors and the test coupling per manufacturer's instructions. Follow the test equipment manufacturer's initial adjustment instructions. Connect Test Jumper-1 between the light source and the power meter. Avoid placing bends in the jumper that are less than 100 mm (4 inches) in diameter.



If the power meter has a Relative Power Measurement Mode, select it. If it does not, reduce the Reference Power Measurement (P_{ref}). If the meter can display power levels in dBm, select this unit of measurement to simplify subsequent calculations.

Disconnect Test Jumper-1 from the power meter. Do NOT disconnect the test jumper from the light source.

Connect Test Jumper-2 between the power meter and Test Jumper-1 using the test coupling. Test Jumper-2 should include a high order mode filter. This can be accomplished by wrapping the jumper three times around a 30 mm (1.2 inches) diameter mandrel.



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REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

Record the Power Measurement (P_{sum}). If the power meter is in Relative Power Measurement Mode, the meter reading represents the CPR value. If the meter does not have a Relative Power Measurement Mode, perform the following calculation:

If P_{sum} and P_{ref} are in the same logarithmic units (dBm, dBu, etc.):
 $CPR (dB) = P_{sum} - P_{ref}$
 If P_{sum} and P_{ref} are in watts:
 $CPR (dB) = 10 \times \log_{10} [P_{sum}/P_{ref}]$

- (2) Single Mode Fiber. The Single Mode Optical Power Meter fiber test shall be conducted as follows:

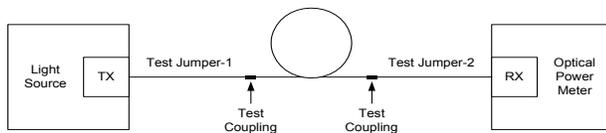
Clean the test jumper connectors and the test coupling per manufacturer's instructions. Follow the test equipment manufacturer's initial adjustment instructions. Connect Test Jumper-1 between the light source and the power meter. Avoid placing bends in the jumper that are less than 100 mm (4 inches) in diameter.



If the power meter has a Relative Power Measurement Mode, select it. If it does not, reduce the Reference Power Measurement (P_{ref}). If the meter can display power levels in dBm, select this unit of measurement to simplify subsequent calculations.

Disconnect Test Jumper-1 from the power meter. Do NOT disconnect the test jumper from the light source.

Attach Test Jumper-1 to one end of the cable plant to be measured and Test Jumper-2 to the other end.



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**REVISION OF SECTION 614
TEST FIBER OPTIC CABLE**

Record the Power Measurement (P_{sum}). If the power meter is in Relative Power Measurement Mode, the meter reading represents the true value. If the meter does not have a Relative Power Measurement Mode, perform the following calculation:

If P_{sum} and P_{ref} are in the same logarithmic units (dBm, dBu, etc.):

$$CPR (dB) = P_{sum} - P_{ref}$$

If P_{sum} and P_{ref} are in watts:

$$CPR (dB) = 10 \times \log_{10} [P_{sum}/P_{ref}]$$

F) Test Acceptance. The Contractor shall demonstrate that each Optical Power Test results in acceptable attenuation values.

The Contractor, solely at the Contractor's cost, shall remake any fusion splices that have test results exceeding acceptable attenuation values.

The Contractor, solely at the Contractor's cost, shall retest any fiber links that have been re-spliced.

The Contractor, solely at the Contractor's cost, shall bring any link not meeting the requirements of this specification into compliance.

G) Submittals. The Contractor shall submit test results documentation as both a hard copy and electronic copy.

After each reel test, the Contractor shall submit four (4) hard copies of the OTDR trace for every fiber on the reel. After installation, the Contractor shall submit four (4) hard copies of the OTDR trace for every spliced fiber. Hard copy traces shall be organized and bound in logical order in an 8 1/2" x 11" 3 ring hard cover binder in addition to other documentation listed in this Special Provision and other splicing documentation listed in the project Special Provision package.

The Contractor shall submit, after approval of the hard copy traces, electronic copies of all traces and appropriate software to allow reading the traces.

The Contractor shall submit four (4) copies of all Optical Power Test results.

The Contractor shall submit four (4) copies of the complete contract Plans, including additional drawings issued as part of any change orders, revisions to the project plans during fiber optic work with any deviations clearly marked in color. Deviations to be noted and shall include but not be limited to the following:

- (1) Fiber Splice location
- (2) Fiber Splice configuration
- (3) Termination layout

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**REVISION OF SECTION 614
TEST FIBER OPTIC CABLE**

Subsection 614.13 shall include the following:

Test Fiber Optic Cable will be measured by on reel testing of all fiber strands complete end-to-end OTDR tests and power meter tests on the fiber, including labor, materials, document submission necessary to complete the work.

**REVISION OF SECTION 614
VIDEO OPTICAL TRANSCEIVER**

Section 614 of the Standard Specifications is hereby revised to include the following:

DESCRIPTION

For this project Video Optical Transceiver shall be a AFI fiber optic transceiver which includes a single video port, programmable data ports and a two (2) RJ-45 IP Ethernet ports. The transceiver shall be used as an Ethernet transceiver for communications between Intelligent Transportation Devices and CISCO Ethernet switches located in field communications cabinets.

MATERIALS

Video Optical Transceivers shall interface with the designated controllers over SMFO cable as supplied by the Contractor. The OTR shall provide an electrical signal interface for three user configurable serial ports (RS-232, RS-422, 2 or 4 wire RS-485, or Manchester data), one additional serial port dedicated to 4 wire RS-485, or Manchester data, two RJ-45 10/100 Mb/s Ethernet ports, NTSC video, and one FC SMFO interface that supports point-to-point Video and Data Optical communication.

The Contractor shall furnish and install all transceivers, power supplies, cabling, and all other related hardware.

Video Optical Transceivers shall consist of the following communications interfaces.

a. IP Communications Interface

On the device end, an Ethernet cable shall be installed from the device controller to the Ethernet port on the optical transceiver. On the Ethernet switch end, an Ethernet cable shall be installed from the optical transceiver port to the associated switch port. The Ethernet cable shall be a UTP cable, Category 6 rated and constructed of 24 AWG stranded copper wires. The outer jacket shall be UV resistant PVC insulation. The Ethernet cable shall be terminated with male 8P8C connectors as a 'straight through' cable using the [Telecommunications Industry Association](#) / Electronic Industries Alliance (TIA/EIA) T- 568B pin/pair assignments.

b. Video Optical Interface

The Video Optical interface to the OTR shall be single mode fiber, with a 9.0 ± 0.5 micron core diameter, via FC/PC connector. Mode fields of either depressed cladding or matched cladding shall be accommodated by the connector. Female connectors shall be provided on the optical transceiver device as follows; the optical transceiver shall include interfaces for single mode point-to-point fiber communication. Video and control data transmission over the OTR pair shall be transparent to connected equipment, requiring no special communications software.

c. Serial Ports

The OTRs shall be shipped to the installation site with the data channels configured as: Data 1 – RS-422, Data 2 – RS-485 4 wire, Data 3 – RS-232 (dip switch selectable). The single RS-485 channel shall be factory set for RS-485 4 wire.

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**REVISION OF SECTION 614
VIDEO OPTICAL TRANSCEIVER**

CONSTRUCTION REQUIREMENTS

The OTR shall be free of sharp edges. Power input requirements (i.e., voltage and current) shall be marked on the OTR case. All power interconnections shall be protected against inadvertent contact by maintenance personnel.

Any safety handling related instructions shall be plainly marked on the OTR case. Bellcore TR-NWT-001089 safety and National Electrical Safety Code (NESC) requirements shall apply to installation of the OTR. The OTR shall comply with FCC Class A requirements. Bellcore TR-NWT-001089 electromagnetic compatibility requirements also shall apply.

METHOD OF MEASUREMENT

Each Video Optical Transceiver will be measured as each for furnishing and installing each Video Optical Transceiver, complete in place, in accordance with the Plans and these Special Provisions. The Video Optical Transceiver shall include the Video Optical transceiver, warranty, documentation, Cat 6 Ethernet cables, all necessary cabling, all equipment and labor necessary and all other items necessary to complete the work.

**REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)**

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing a Light Emitting Diode Variable Message Sign (LED VMS) a minimum size of 8 foot by 18 foot and associated equipment cabinets at locations as shown in the plans. The sign shall be fully compatible with the mounting hardware and support structure shown on the plans. The LED VMS shall be equipped with the ability to display 3 lines of text at a height of 18-inch tall characters and shall have a display made up of a full matrix configuration. The matrix shall be a minimum of 27 pixels high by 105 pixels wide. The sign shall include a power shut off mounted to the sign structure near the controller interface cabinet. The sign shall be capable of operating without any decrease in performance over a temperature range of -40° F to +158° F with a relative humidity of 0 to 100 percent, condensing. The sign shall have a minimum design life of 20 years.

MATERIALS

a) *Certifications:* Prior to start of the installation of the LED VMS the Contractor shall provide the following certifications to the Engineer for review and approval:

- (1) Certification showing that the manufacturer of the LED VMS is fully compliant with ISO 9001 as of the bid date for this project. The ISO 9001 Certification shall apply to the facility, and to the design, fabrication, installation, and maintenance of the LED VMS. The facility where this company actually designs and manufactures the LED VMS shall be ISO 9001:2000 certified a minimum of one year prior to the bid date for this project.
- (2) Working drawings showing the sign housing and tilting brackets shall be sealed by an Engineer registered in the State of Colorado and shall be submitted in accordance with subsection 105.02.
- (3) Certification showing that welding of the LED VMS housing is in accordance with the American Welding Society (AWS) Standards, ANSI/AWS D1.2-97. The LED VMS manufacturer's welders and welding procedures shall be certified by an ANSI/AWS Certified Welding Inspector to the ANSI/AWS D1.2-97 Structural Welding Code for Aluminum.
- (4) Certification that all aluminum face materials have a coating that meets or exceeds the requirements of the American Architectural Manufacturers Association (AAMA) Specifications Publication No. 2605.
- (5) Certification that the LEDs were tested and binned in accordance with the CIE Test Method A.
- (6) Documentation and information on software as described in Appendix A of this document.
- (7) Documentation verifying the VMS is listed by an accredited 3rd party testing organization for conformance to UL48 and UL 1433.
- (8) All workmanship shall comply with IPC-A-610C, Class 2 titled "Acceptability of Electronic Assemblies".
- (9) Documentation providing proof PCB silicon conformal coating conformance to MIL-I-46058C Type SR and IPC-CC-830.

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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

(10) Documentation that the sign's structural integrity is in Conformance to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals (Third Draft).

(11) Documentation that the VMS conforms to the Transient Protection and Vibration of the NEMA Standard TS4, Section2.

b) *Sign Housing:* All component parts shall be easily and readily accessible by a single person for inspection and maintenance. There shall be room for a technician to work. Access shall be made by entering the side of the housing. The housing shall be weather tight, and compliant to the NEMA 3R Standard. The bottom panel of the housing shall have a minimum of four drain holes, with snap-in, drain filter plug inserts.

The sign housing shall be capable of withstanding a wind loading of 120 mph without permanent deformation or other damages. The sign housing shall also be designed, stamped and signed by a Professional Engineer licensed in Colorado to withstand current AASHTO specified group loading combinations including: sign weight, repair personnel and equipment, ice and wind loads. It shall also meet strength requirements for truck-induced gusts as specified in NCHRP Report 412. The sign housing shall be engineered to withstand snow loading of 40 pounds per square foot, as well as the ability to be mounted in a manner that prevents the buildup of snow and creates a natural means by which snow can run off without impeding flow of traffic.

The performance of the sign, including the visibility and legibility of the display, shall not be impaired due to continuous vibration caused by wind, traffic or other factors. The housing shall be designed to accommodate mounting on the rear vertical plane and shall be structurally sufficient to be mounted to the sign support structure. The sign housing and structural components for the tilting system including bolts and welds, shall be structurally sufficient to perform under all applicable loading conditions including gravity, wind, traffic, weather, roadway deicers, maintenance, and other environmental factors. Working drawings showing the sign housing and tilting brackets shall be submitted in accordance with subsection 105.02. Working drawings shall be sealed and signed by an Engineer registered in the State of Colorado.

All parts shall be made of corrosion resistant materials, such as plastic, stainless steel or aluminum. Painted steel is not acceptable. No self-tapping screws shall be used. The exterior front face surfaces shall be finish coated by a system that meets or exceeds the AAMA Specification No. 2605. The finish shall be matte black. The main body of the sign housing shall be constructed of aluminum with a natural mill finish. All exterior seams shall be continuously welded by an inert gas process, except for the coated fascia material.

The glazing shall be constructed of 0.25 inch thick clear GE LEXAN XL10 or pre-approved equivalent polycarbonate sheets with surfaces that resist hazing from UV light. The glazing shall be protected by a coated 0.090 inch aluminum mask with apertures punched directly in front of each pixel. The coating shall meet or exceed the AAMA Specification No. 2605.

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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

The external front face panels shall have the following minimum dimensions: The perimeter panels shall be a minimum of 12 inches wide. The external front face panels shall be thermally insulated from the rest of the sign housing. The glazing, aluminum mask and the external front face panels shall be easily replaceable from within the sign housing. The ventilation system shall be forced air. The system shall be designed to adequately cool the pixels from all sides along with the front and rear of the display module and all other internal components. The ventilation system shall have the following properties:

- (1) Positive pressure (exhaust fans are not acceptable).
 - (2) The fans shall have ball or roller bearings, shall be permanently lubricated and shall require no periodic maintenance. The fans are to be positioned in such a manner so as to provide a balanced air flow to the ventilation system in the event of failure of any fan.
- The sign housing shall be provided with a flush-mounted, 150 degree swing, right hinge, heavy-duty, personnel access door with hoisting hardware on door frame that will provide easy access for a single maintenance person.

The door shall be constructed of aluminum with a welded aluminum frame and equipped with two closed cell neoprene gaskets. One gasket shall be attached to the door and one gasket shall be attached to the housing door jamb. The housing door shall be attached to the housing with a stainless steel piano hinge with a stainless steel pin spot welded at the top. The hinge shall be mounted so that it is not possible to remove it from the door or cabinet without first opening the door. The door and hinges shall be braced to withstand a 100 pound per vertical foot of door height load applied vertically to the outer edge of the door when standing open. There shall be no permanent deformation or impairment of any part of the door or cabinet body when the load is removed. The door opening shall be double flanged on all four sides. The cabinet door shall also be pad-lockable.

It shall include a three-point locking mechanism with two operating handles, and a dead bolt center-case lock. The lock mechanism and handles shall be corrosion resistant. The door operating handles shall be on both the inside and outside of the door. The door assembly shall also include a device to hold the door open from 90 to 150 degrees.

The door shall be provided with a door alarm that is controlled by the sign controller and notifies the Central system control software whenever the door is accessed.

The sign housing shall have a continuous, interior walkway (minimum 24" width) extending the full length of the sign. The internal structural members shall be extruded aluminum and shall accommodate both the display module mountings while allowing air distribution. The display modules shall be removed and replaced without the use of tools and without disturbing adjacent modules. A fold down aluminum shelf shall be provided in the sign housing next to the 2070 controller and in the controller interface cabinet. The sign shall have baseboard heaters that are sufficient to elevate the temperature within the sign to 30° F above the temperature outside the sign. These heaters shall be controlled by a wind up timer in the sign and remotely from the controller interface cabinet and central computers.

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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

The angular alignment of the sign housing shall be adjustable in the vertical direction from (0 to 10 degrees) down in one-degree increments to optimize the viewing angle.

For surge protection, the system power shall be protected by two stages of transient voltage suppression devices. Also, communication lines shall be protected by two stages of transient voltage suppression devices as required in the Sign Controller Communication Interface section of this specification. In both cases, tripping of each stage (or both if tripped simultaneously) of the surge protection shall cause the sign controller to call central and report the error condition (for dialup operation) or report the error condition to central on the next poll (for multi-drop operation). There shall be an option that is either enabled or disabled and is selected and downloaded from the central system control software to the sign controller. When this option is enabled, tripping of the second stage of surge protection shall prevent power from reaching any components of the sign until the surge protection has been replaced. When this option is disabled, the sign will continue to function normally after the second stage of surge protection is tripped.

c) *Sign controller:* The sign controller shall be mounted in the sign housing. The sign controller shall be a multiple-sourced, non-proprietary, NTCIP compliant, 19 inch rack mountable, 2070 ATC (Lite) traffic controller, and shall be provided with resident software stored in non-volatile memory. The housing shall be backwards compatible with a standard 2070 traffic controller chassis currently in use. The 2070 ATC controller shall have the capability of upgrading to ATC 5.2b (Linux) specifications.

The 2070 ATC (Lite) shall include a minimum of seven (7) serial communications I/O ports, including three (3) RS-232 ports and one (1) Ethernet port, 2070 accessories 2070-7A serial communication module, 2070-2B field I/O module, 2070-1B CPU Module, and a 2070-4A power supply module shall be supplied as the minimum. The 2070 ATC (Lite) shall have the latest OS-9 (or Linux) operating system.

The sign controller shall be programmed to receive and transmit NTCIP compliant sign control commands from the central system control software or laptop computer.

The controller shall have power-up and auto-restart capabilities with programmable default actions when recovering from a power off condition. A hardware watch dog circuit shall provide automatic reset of the controller and modem device. Central control shall have ability to perform a remote command for the controller and modem device reset.

The Controller shall perform all communication, control and feedback functions and shall not require an intermediate control device and be the only sign controller. Communication and control lines between the sign controller and the system interface circuits shall be opto-coupled.

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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

The following shall be mounted inside the main sign housing:

- (1) NTCIP compliant 2070 ATC (Lite) sign controller
- (2) Fold-down laptop shelf and document holder for maintaining sign.
- (3) Modem/or communication device
- (4) Display system interface circuits
- (5) Local/remote control switch
- (6) Sign to ground voice communication RJ-11 jack
- (7) USB plug-in connection or a serial connection with a USB converter cable for the controller interface.
- (8) RS-232 cable (a minimum of 4 feet long to connect the controller interface to a laptop computer)
- (9) A.C. surge protection and communication surge protection

There shall be an outside controller interface box that shall be made of aluminum or stainless steel, be weather tight, corrosion resistant, and meet NEMA 3R standards. The separate controller interface box shall be mounted as indicated on the plans. This typically will be on the sign support structure pole furthest from traffic.

The controller interface cabinet shall contain the following assemblies:

- (1) Power-on indicator
- (2) Waterproof local/remote switch
- (3) Local control LED indicator
- (4) RS-232cable a minimum of 4 feet long to connect the controller interface to a laptop computer.
- (5) 120 VAC GFI outlet
- (6) For dialup installations, an RJ-11 jack for connecting the dialup phone line shall be installed with in-line surge protection.

d) Electronics: All electronic components, except printed circuit boards, shall be commercially available, easily accessible, replaceable and individually removable using conventional electronics repair methods.

All Printed Circuit Boards (PCBs) shall be completely conformal coated with a silicone resin that meets the IPC CC-830 standard. The exception for this coating shall be the pixels on the front of the PCB of the LED motherboards and any components in sockets.
All discrete components, such as resistors, capacitors, diodes, transistors, and integrated circuits shall be individually replaceable. Components shall be arranged so they are easily accessible for testing and replacement. All circuit designs shall utilize high quality electronic components and shall provide a meantime before failure of at least 3 years.

Provisions shall be made to prevent face fogging and condensation. The sign controller shall read the internal temperature sensors, external ambient temperature sensor and the

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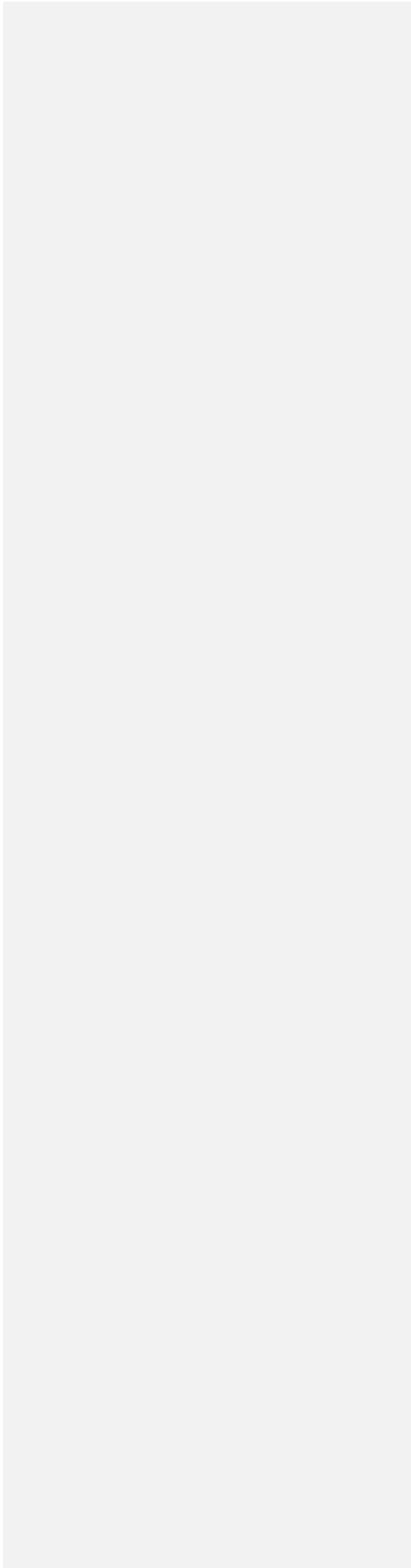
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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

humidity sensor. The sign controller shall use these readings in an algorithm that turns on the heat tape to reduce both frost on the face of the sign and condensation on the display modules and other electronic circuitry.

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The sign and the controller shall be capable of operating with 120/240 VAC, 50 amp per leg, 60 Hz, single phase power. The sign shall have a 50-amp two-pole breaker (common trip) main, 120/240 VAC, single phase, four wire load center with 20 circuit capability. Each circuit in the sign shall be powered from a circuit breaker. Inside the sign housing, all 120 VAC service lines shall be independently protected by a thermomagnetic circuit breaker at the sign housing entry point. All 120 VAC wiring shall be located in conduit, pull boxes, raceways, or control cabinets as required by the National Electrical Code (NEC). No 120 VAC wiring shall be exposed within or outside of the sign housing. The sign housing shall not be considered as a raceway or control cabinet. There shall be a minimum of three GFI Duplex outlets installed inside the sign housing.

Lighting shall be provided to illuminate the interior of the sign. The lights shall be enclosed in die cast aluminum safety fixtures with twist-on bulb guards secured by four set- screws. The light bulbs shall be clear incandescent light bulbs that may be controlled by an adjustable timer.

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The pixels shall be amber in color and utilize precision optical performance AlInGaP II LEDs constructed of aluminum indium gallium phosphide. The brightness and color of each pixel shall be uniform over the entire face of the sign within the 15-degree cone of vision from minimum of 200 feet up to and including 1100 feet in all lighting conditions. Each pixel shall be 40 candelas at 20mA as measured by the sum of the brightness of the individual LEDs in each pixel. The brightness of each LED shall be measured in accordance with CIE Test Method A, as described in CIE 127-1997, Technical Report: Measurement of LEDs.

Each pixel shall contain two strings of LEDs. The pixel strings shall be powered from a regulated DC power source and the LED current shall be maintained at 25 plus or minus three milliamperes per string to maximize life of the pixel. The failure of an LED in one string within a pixel shall not affect the operation of any other string or pixel. The LEDs shall be capable of operating in a temperature range of -40 degrees to +100 degrees C. The LED junction temperature of 130 °C. The LEDs shall be moisture resistant epoxy with UV-A and UV-B inhibitors.

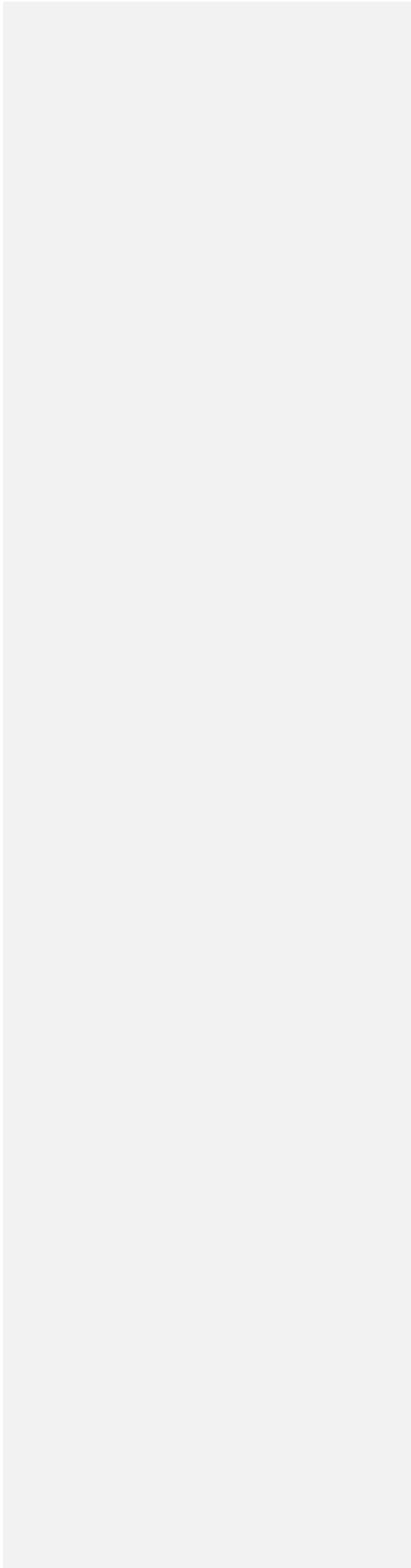
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Pixel power drawn from the DC supplies shall not exceed 1.5 watts per pixel, including the driving circuitry.

A minimum of three photocells shall be installed on the sign. These devices shall permit automatic light intensity measurement of light conditions at each sign location. These photocells shall be mounted in a manner to measure front, rear and ambient light conditions.

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Provisions shall be made to prevent perceivable brightening of the sign due to stray headlights shining upon the photo sensors at night.



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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

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 40% of all pixels.

All cables shall be securely clamped/tied in the sign housing. No adhesive attachments will be allowed.

The signs shall be capable of displaying ASCII characters 32 through 126 (including all upper and lower case letters and digits from 0 to 9) at any location in a message line.
The Contractor shall be responsible for locating the nearest electrical power and telephone sources and connecting those sources to the appropriate terminations with the LED VMS.
The Contractor shall cooperate with the local electrical and telephone utilities to establish a service accounts at the direction of the Engineer.

e) *Communication:* The sign controller shall be capable of being controlled from the central system control software and the controller interface cabinet via RS-232 serial and Ethernet communications.

The sign controller shall include separate interfaces for communication with the central system control software and the controller interface cabinet.

The communications between the sign controller and the central system control software and controller interface cabinet shall comply with the NEMA National Transportation Communications for ITS Protocol (NTCIP). The sign controller shall support all NTCIP conformance levels, conformance groups, objects, and minimum storage sizes and ranges as specified in APPENDIX A.

In addition to the standard Management Information Base (MIB) objects, the sign shall include any additional manufacturer-specific MIB objects required to support all of the sign and central software functionality defined in this specification and in APPENDIX A.

Dial-up or hardwire multi-drop communication lines shall be protected by two stages of transient voltage suppression devices including MOVs and spark gap arrestor.

The sign controller shall be capable of being remotely reset from the central system control software.

The sign shall provide a minimum of four (4) input and four (4) output contact closures able to receive digital and or analog signals that will allow up to 15 message activations upon contact closure events. These message activations shall permit standard NTCIP operations to occur and also permit contact closure messages to occur without message activation collisions and or message activation errors. Contact closures shall be remotely accessible using standard NTCIP MIB objects. Contact closures shall be capable of issuing NTCIP traps.

The sign controller shall provide software modules that will allow integration with CDOT WIM systems.

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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

The sign controller shall allow user-configuration of maximum and minimum temperature in which to turn fans on and off.

The sign shall have polling capability and at a minimum shall be capable of reporting the status of the following:

- (1) Pixel operational status that includes every string of every pixel
- (2) Sign and ambient temperature
- (3) DC power supply status
- (4) The current state (on or off) of each pixel, including any pixel errors, in the actual, currently displayed message without disturbing the message in any way. This shall be real time and shall not be based on a previous pixel test.
- (5) Cooling fan status
- (6) Access door alarm
- (7) Communication failure log
- (8) Heat tape status
- (9) UPS status
- (10) AC surge protector status

The controller software shall be capable of displaying the following types of messages:

- (1) Static messages capable of displaying any character or set of characters
- (2) Full Graphic capabilities.
- (3) Flashing messages with the following ranges of adjustable timing:
 - (a) Message time on from 0.5 to 5.0 seconds in 0.1 second increments.
 - (b) Message time off from 0.5 to 5.0 seconds in 0.1 second increments.
- (4) Alternating messages capable with the following ranges of adjustable timing:
 - (a) Primary message time on from 0.5 to 5.0 seconds in 0.1 second increments.
 - (b) Primary message time off from 0 to 5.0 seconds in 0.1 second increments.
 - (c) Alternate message time on from 0.5 to 5.0 seconds in 0.1 second increments.
 - (d) Alternate message time off from 0 to 5.0 seconds in 0.1 second increments.

It shall be possible to flash any character or set of characters in an alternating message at the adjustable frequencies listed above for flashing messages. The flashing period shall be a sub-multiple of the associated alternating on time. It shall also be possible to flash any character or set of characters in a static message.

The sign controller shall monitor the photo cell circuits in the sign and convert the measured light intensity into the desired pixel brightness.

MANUFACTURER QUALIFICATIONS

The manufacturer shall supply experience documentation showing that the manufacturer has been in business, under the current corporate name, designing and manufacturing Interstate LED Variable Message Signs for a minimum of 5 years; and that the manufacturer has in

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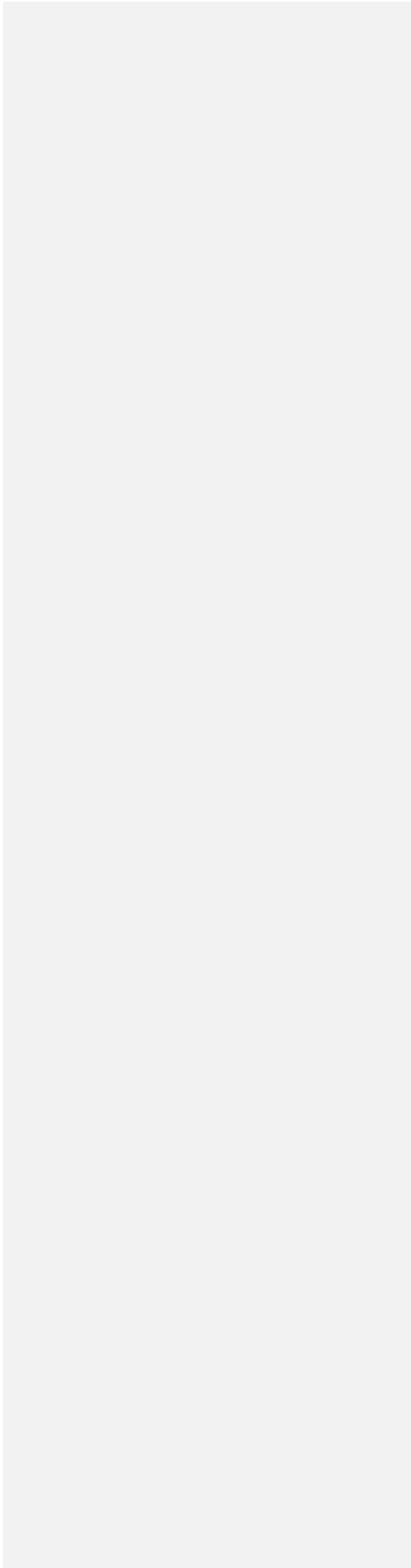
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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

operation a minimum of 100 walk-in LED VMSs. These 100 VMS shall be from 5 separate projects and operational for a minimum of 5 years.

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CONSTRUCTION REQUIREMENTS

Contractor shall be fully responsible for the delivery of the sign to the installation site and any damages that occur in the installation delivery process.

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The LED VMS shall be installed in accordance with manufacturer's recommendations. A qualified factory representative shall be available on site to ensure proper installation and testing.

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The Contractor shall perform a VMS acceptance test procedure for approval and acceptance by the Department in the presence of the Engineer, a representative of the CDOT Colorado Transportation Management Center, and the manufacturer's representative. The test shall include all items addressed in these specifications and any other requirements from the project plans or Engineer. The test shall also include the use of the latest version of the NTCIP Exerciser, or equivalent, to demonstrate that no proprietary protocols have been used and that the local and central software are NTCIP compliant. The Contractor shall notify the Engineer at least two weeks prior to the test date.

A minimum of five copies of the operations manual detailing the electrical schematics, operation and maintenance of the VMS system, including spare software copies, shall be provided. Additional copies may be requested by the Engineer. One copy of the manual shall remain inside the sign housing or control cabinet. One copy shall be mailed to the Colorado Transportation Management Center at 425 C Corporate Circle, Golden, Colorado 80401.

WARRANTY

a) Standard Warranty. The contractor shall ensure that the manufacturer can warranty the product for a minimum of 3 years for all parts returned to the factory, and full telephone technical support at no additional charge to the Department. The technical support shall include access to a trained service representative who can respond within 24 hours to questions related to all VMS related equipment problems and maintenance issues.

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METHOD OF MEASUREMENT

The LED VMS will be measured by the actual number that are installed and accepted, and shall include all labor, materials, and equipment necessary to complete the work, including the sign controller, controller interface box, sign housing, electronics, communications equipment, delivery to the installation site and standard warranty.

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BASIS OF PAYMENT

Payment will be made in accordance with the following:

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All costs associated with having a manufacturer's representative on-site will not be measured and paid for separately, but shall be included in the work.

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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

All costs associated with training and the purchasing of manuals will not be measured and paid for separately, but shall be included in the work.

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All costs associated with the delivery of the sign to the installation site will not be measured and paid for separately, but shall be included in the work.

Electrical and telephone demark service connections from the power and telephone sources to the appropriate terminations with the LED VMS will be paid for by Force Account in accordance with subsection 109.04.

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Appendix A

NTCIP Requirements

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

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This specification references several standards through their NTCIP designated names. The following list provides the full reference to the current version of each of these standards. In many cases, the standard is more widely known by its original NEMA assigned number, in these cases, the NEMA number is also identified. The content of the NEMA standard is identical to that of the NTCIP standard. Each NTCIP Component covered by these project specifications shall implement the most recent version of the standard that is at the stage of Recommended or higher as of Sunday, April 03, 2001, including any and all Approved or Recommended Amendments to these standards as of the same date. It is the ultimate responsibility of the vendor to monitor NTCIP activities to discover any more recent documents.

General Requirements:

Subnet Level

Each NTCIP Component shall support NTCIP 2103 v01.05 over both a null-modem connection and a contractor-provided external dial-up modem connection. The dial-up modem shall support data rates of 14.4 kbps, 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps. The null-modem shall support the same speeds with a maximum of 19.2 kbps. Additionally, the NTCIP Component shall be able to make outgoing and receive incoming calls as necessary and support the following modem command sets:

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- Hayes AT Command Set
- MNP5
- MNP10
- V.42bis

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NTCIP Components may support additional Subnet Profiles at the vendor's option. At any one time, only one Subnet Profiles shall be active on a given serial port of the NTCIP Component. If the NTCIP Component has a serial port that supports multiple Subnet Profiles, the NTCIP

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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

Component shall be configurable to allow the field technician to activate the desired Subnet Profile and shall provide a visual indication of the currently selected Subnet Profile.

Transport Level

Each NTCIP Component shall comply with NTCIP 2202, (NEMA TS 3.Internet). NTCIP Components may support additional Transport Profiles at the manufacturer's option. Response datagrams shall use the same Transport Profile used in the request. Each NTCIP Component shall support the receipt of datagrams conforming to any of the identified Transport Profiles at any time.

Application Level

Each DMS shall comply with NTCIP 2301, (NEMA TS 3.AP-STMF), as a Managed Agent and shall meet the requirements for Conformance Level 1 (NOTE – See Amendment to standard). SNMP shall be required and STMP shall not be required. An NTCIP Component may support additional Application Profiles at the manufacturer's option. Responses shall use the same Application Profile used by the request. Each NTCIP Component shall support the receipt of Application data packets at any time allowed by the subject standards.

Information Level

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

The vendor's software shall implement all mandatory objects of the mandatory conformance group defined in NTCIP 1201, (NEMA TS 3.4) Global Object Definitions:

- 1) Configuration Conformance Group – Section 3.1
- 2) Security Conformance Group (new in Amendment 1)

The vendor's software shall implement the mandatory objects of the optional conformance groups defined in NTCIP 1201, (NEMA TS 3.4), Global Object Definitions:

- Time Management Conformance Group – Section 3.3
- TimeBase Event Schedule Conformance Group – Section 3.4
- Report Conformance Group – Section 3.5

The vendor's software shall implement all mandatory objects of all mandatory conformance groups defined in NTCIP 1203, (NEMA TS 3.6) Object Definitions for Dynamic Message Signs:

- Sign Configuration Conformance Group – Section 4.1

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- [Message Table Conformance Group – Section 4.6](#)
- [Sign Control Conformance Group – Section 4.7](#)

The vendor's software shall implement all mandatory objects of the optional conformance groups defined in NTCIP 1203, (NEMA TS 3.6), Object Definitions for Dynamic Message Signs:

- [GUI Appearance – Section 4.2](#)
- [Font Definition – Section 4.3](#)
- [DMS Sign Configuration – Section 4.4](#)

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VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

- [MULTI Configuration – Section 4.5](#)
- [Default Message – Section 4.8](#)
- [MULTI Error – Section 4.10](#)
- [Illumination/Brightness – Section 4.11](#)
- [Scheduling – Section 4.12](#)
- [Auxiliary I/O – Section 4.13](#)
- [Sign Status – Section 4.14](#)
- [Status Error – Section 4.15](#)
- [Pixel Error Status – Section 4.16](#)
- [Fan Error Status – Section 4.18](#)
- [Temperature Status – Section 4.17](#)

The vendor's software shall implement the following optional objects defined in NTCIP 1203, (NEMA TS 3.6):

- [dmsMessageBeacon – Section 2.6.1.1.1.8.6](#)
- [dmsSWReset – Section 2.7.1.1.1.1](#)
- [dmsMessageTimeRemaining – Section 2.7.1.1.1.4](#)
- [dmsShortPowerRecoveryMessage – Section 2.7.1.1.1.8](#)
- [dmsLongPowerRecoveryMessage – Section 2.7.1.1.1.9](#)
- [dmsShortPowerLossTime – Section 2.7.1.1.1.10](#)
- [dmsResetMessage – Section 2.7.1.1.1.11](#)
- [dmsCommunicationsLossMessage – Section 2.7.1.1.1.12](#)
- [dmsTimeCommLoss – Section 2.7.1.1.1.13](#)
- [dmsPowerLossMessage – Section 2.7.1.1.1.14](#)
- [dmsEndDurationMessage – Section 2.7.1.1.1.15](#)
- [dmsMultiOtherErrorDescription – Section 2.7.1.1.1.20](#)
- [dmsStatDoorOpen – Section 2.11.1.1.1.6](#)
- [fanFailures – Section 2.11.2.1.1.8](#)
- [fanTestActivation – Section 2.11.2.1.1.9](#)
- [tempMinCtrlCabinet – Section 2.11.4.1.1.1](#)
- [tempMaxCtrlCabinet – Section 2.11.4.1.1.2](#)
- [tempMinAmbient – Section 2.11.4.1.1.3](#)
- [tempMaxAmbient – Section 2.11.4.1.1.4](#)
- [tempMinSignHousing – Section 2.11.4.1.1.5](#)
- [tempMaxSignHousing – Section 2.11.4.1.1.6](#)

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The vendor's software shall implement the following tags (opening and closing where defined) of MULTI as defined in NTCIP 1203, (NEMA TS 3.6), Object Definitions for Dynamic Message Signs:

MULTI Tag

- 1 Field
- 2 Flash
- 3 Font
- 4 Hexadecimal Character

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**REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)**

- 5 Justification Line
- 6 Justification Page
- 7 Moving Text
- 8 New Line
- 9 New Page
- 10 Page Time
- 11 Spacing – Character

The Field Tag shall support the following field ID's:

Field Tag ID Description

Field Tag ID	Description
1	1 Time, 12-hour format (no AM/PM indicator)
2	2 Time, 24-hour format
3	3 Temperature in degrees Celsius
4	4 Temperature in degrees Fahrenheit
5	7 Day of week
6	8 Day of month
7	9 Month of year
8	10 Year, 2-digits
9	11 Year, 4-digits

Sizes and Ranges

All objects required by these procurement specifications shall support all values within its standardized range, unless otherwise approved by the Project Engineer. The standardized range is defined by a size, range, or enumerated listing indicated in the object's SYNTAX field and/or through descriptive text in the object's DESCRIPTION field of the relevant standard. The following provides the current listing of known variances for this project:

Object Reference Minimum Project Requirements

NTCIP 1201 (TS 3.4)

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<u>moduleTableEntry</u>	<u>2.2.3</u>	<u>Shall contain at least one row with moduleType equal to 3 (software). The moduleMake shall specify the name of the manufacturer, the moduleModel shall specify the manufacturer's name of the component and the modelVersion shall indicate the model version number of the component.</u>
<u>communityNamesMax</u>	<u>2.8.2</u>	<u>Shall be at least 4.</u>
<u>maxTimeBaseScheduleEntries</u>	<u>2.4.3.1</u>	<u>7</u>
<u>maxDayPlans</u>	<u>2.4.4.1</u>	<u>7</u>
<u>maxDayPlanEvents</u>	<u>2.4.4.2</u>	<u>7</u>
<u>maxEventLogConfigs</u>	<u>2.5.1</u>	<u>50</u>
<u>eventConfigMode</u>	<u>2.5.2.3</u>	<u>2,3,and 4</u>

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**REVISION OF SECTION 614
 VARIABLE MESSAGE SIGN (LED) (OVERHEAD)**

<u>maxEventLogSize</u>	<u>2.5.3</u>	<u>200</u>
<u>maxEventClasses</u>	<u>2.5.5</u>	<u>7</u>
<u>maxGroupAddress</u>	<u>2.7.1</u>	<u>1</u>

NTCIP 1203 (TS 3.6)

<u>dmsNumPermanentMsg</u>	<u>2.6.1.1.1.1</u>	<u>50</u>
<u>dmsMaxChangeableMsg</u>	<u>2.6.1.1.1.3</u>	<u>50</u>
<u>dmsFreeChangeableMemory</u>	<u>2.6.1.1.1.4</u>	<u>50KB</u>
<u>dmsMaxVolatileMsg</u>	<u>2.6.1.1.1.6</u>	<u>50</u>
<u>dmsFreeVolatileMemory</u>	<u>2.6.1.1.1.7</u>	<u>50KB</u>
<u>dmsMsgMultiString</u>	<u>2.6.1.1.1.8.3</u>	<u>See attached table</u>

NTCIP 1203 (TS 3.6) (continued)

<u>dmsControlMode</u>	<u>2.7.1.1.1.1</u>	<u>2,4,5</u>
<u>numFonts</u>	<u>2.4.1.1.1.1</u>	<u>4</u>
<u>maxFontCharacters</u>	<u>2.4.1.1.1.3</u>	<u>127</u>
<u>vmsCharacterHeightPixels</u>	<u>2.3.1.1.1.1</u>	<u>5</u>
<u>vmsCharacterWidthPixels</u>	<u>2.3.1.1.1.2</u>	<u>7</u>
<u>vmsSignHeightPixels</u>	<u>2.3.1.1.1.3</u>	<u>3</u>
<u>vmsSignWidthPixels</u>	<u>2.3.1.1.1.4</u>	<u>10</u>
<u>vmsHorizontalPitch</u>	<u>2.3.1.1.1.5</u>	<u>70mm</u>
<u>vmsVerticalPitch</u>	<u>2.3.1.1.1.6</u>	<u>70mm</u>
<u>defaultBackgroundColor</u>	<u>2.5.1.1.1.1</u>	<u>0 (black)</u>
<u>defaultForegroundColor</u>	<u>2.5.1.1.1.2</u>	<u>9 (amber)</u>
<u>defaultJustificationLine</u>	<u>2.5.1.1.1.6</u>	<u>2,3,4</u>
<u>defaultJustificationPage</u>	<u>2.5.1.1.1.7</u>	<u>2,3,4</u>
<u>defaultFlashOn</u>	<u>2.5.1.1.1.3</u>	<u>0.5 to 5.0</u>
<u>defaultFlashOff</u>	<u>2.5.1.1.1.4</u>	<u>0.5 to 5.0</u>
<u>defaultPageOnTime</u>	<u>2.5.1.1.1.8</u>	<u>0.5 to 5.0</u>
<u>defaultPageOffTime</u>	<u>2.5.1.1.1.9</u>	<u>0.5 to 5.0</u>
<u>defaultCharacterSet</u>	<u>2.5.1.1.1.10</u>	<u>eightBit (2)</u>
<u>numActionTableEntries</u>	<u>2.9.1.1.1.1</u>	<u>15</u>

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Documentation

Software shall be supplied with full documentation, including 3.5" floppy disk(s) and a CD-Rom containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

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

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**REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)**

- A MIB Module in ASN.1 format containing any and all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.
- A MIB containing any other objects supported by the device.

The vendor shall allow the use of any and all of this documentation by any party authorized by CDOT for systems integration purposes at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

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REVISION OF SECTION 620
FIELD FACILITIES

Electrical Grounding:

Proper grounding is important to protect occupants using computer equipment and phones in the event of electrical storms and also for the protection of the equipment itself.

If the site will have two field trailers, where one Trailer will serve as the office and the other will serve as the lab, the two trailers will set together and share a common electrical ground so computer cabling can installed without spanning driveways.

Telephones & Cabling:

Telephone lines shall be of type full business (1FB).

The number of line to be determined by the Section 2 - Project Management.

Order phone lines through the Telco provider's (CenturyTel, etc.) business office to optimize cost efficiencies with regard to basic, local and long distance plans and charges.

The Contractor shall be responsible for maintaining all phones and circuits in good operating condition at all times during this project.

High Speed Internet:

Note: The contractor shall contact CDOT Regional Network Analyst (Mike Vencius 719-546-5737) for most recent specifications of required network equipment (see Network Equipment section below) and of high-speed provider restrictions and limitations.

The contractor shall provide the field location with high-speed internet connection and equipment. Important note: High Speed Internet access can be difficult to achieve in rural areas.

It is strongly recommended that site selection for the CDOT Office Facilities be made with consideration of the availability of High Speed Internet access. If none is available, the CDOT project manager will be notified immediately in case site relocation is necessary.

The type of High Speed Connection shall preferably be of DSL type. The throughput shall be a minimum of 3 Mbps or better speed. IP addressing shall be DHCP. If the DSL is to serve more than 6 computers, it is recommended that additional DSL circuits be provided.

The use of Wifi is acceptable provided the service remains as fast and stable as Cat 5e cable and not obstructed by electronic interference (microwaves, generators,etc.) or by distance which will impair the signal.

If DSL is not available, Cable or WDSL (Wireless DSL) or a 4G "Cellular" from VerizonWireless or AT&T device that provides internet service to multiple computers may suffice if above specified throughput speeds are achieved.

As a last resort Aircards for each computer perhaps augmented with a cellular signal booster equipment may suffice.

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REVISION OF SECTION 620
FIELD FACILITIES

A UPS (battery Backup) of a minimum rating of 500va (volt amp) needs to be provided to protect the Internet equipment.

Note that satellite type broadband will NOT work for CDOT purposes.

Network Equipment:

If there are multiple trailers or buildings on site the contractor will need to provide the cabling and surge suppression equipment necessary.

The contractor MAY also need to provide additional equipment needed for CDOT network security. Note that this equipment is in addition to the DSL modem provided by the internet provider.

If CDOT computers will reside in more than one trailer, as with a MAT lab, then fiber and transceivers or cat 5e cooper cabling with surge suppressors will need to be purchased and installed as per CDOT IT.

Contact the CDOT Regional Network Analyst for current specifications for this network equipment. Procuring this equipment may take time, so haste in contacting the CDOT Regional Network Analyst is recommended. It is not unusual for this equipment to take over a month to procure due to back orders.

Contact CDOT Regional Network Analyst (Mike Vencius 719-546-5737).

Note: If Cisco network equipment is deemed required by CDOT IT then the current cost of this specialized equipment is approximately \$800.00 to \$1300.00 depending on site requirements. If Cisco equipment is not needed the cost will be determined on whether additional buildings are needed to be connected. The cost here may range from \$100 to \$500. If No Cisco equipment is needed and no additional buildings need to be connected and if the Wifi is available, there may be no additional cost for Network Equipment.

Important Cyber Security issue: At project conclusion, all network equipment (if provided) will be returned to CDOT Regional Network Analyst for removal of CDOT confidential data and network configuration.

Facsimile Machine (if needed): The Project Engineer must approve this machine. The facsimile machine shall print on plain paper and may need to be capable of sending documents of all sizes up to and including 11"x17". It must be able to perform sequential broadcast, polling and delayed transmissions with a minimum ten-page memory. The Contractor shall install and maintain the fax machine in the Engineer's field office. Should the fax machine require repair and be out of service for more than twenty-four hours, a replacement is to be provided and installed by contractor within twenty-four hours. The Contractor shall provide a roll around stand for the fax machine paper and supplies.

Contractor will provide and maintain stock of printer paper and toner.

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**REVISION OF SECTION 620
FIELD FACILITIES**

Note: An All-In-One type printer/scanner/fax may be used if acceptable to the CDOT Project Manager.

Computer Accessories: CDOT has restrictions and limitations with regard to the type of equipment permitted to be connected and supported on its computers and network. Due to the constantly changing nature of the computer field, contact the CDOT Regional Network Analyst for latest recommendations and cautions before purchasing any requested equipment such as printers, scanners, cameras, etc.

It is imperative that any accessories be compatible with the CDOT standard computer operation system: Windows 7 64 bit.

Warning: Many devices will not work on the required 64 bit version, but only on the more common consumer Windows 32 bit version. Make sure the product states Windows 7, **64bit** compatible.

Also, Printers, if requested, may not be networked or shared across networks for example between the CDOT network and non-CDOT computer network. The printer must be directly connected to a CDOT computer and can then be shared for use by other CDOT computers.

Copy/Fax/Scanner/Network Printer units that create PDF files and rely on connectivity across the CDOT IP network violate CDOT cyber security policies and are not permitted to be installed on the CDOT network.

All equipment is to be new with warranties.

Contractor will provide and maintain stock of printer paper and toner for any provided printers, scanners, fax machines.

**REVISION OF SECTION 624
DRAINAGE PIPE**

Subsection 624.03 shall include the following:

Joint systems irrigation systems, cross drains, and storm drains shall be watertight. Testing of joints shall be performed by the Contractor in accordance with approved methods. Should any section of irrigation system, cross drains, and/or storm drains fail to meet the test requirements, it shall be corrected at the Contractor's expense.

**REVISION OF SECTIONS 627
EPOXY PAVEMENT MARKING**

Section 627 is hereby revised for this project as follows:

Section 627.05 of the Standard Specifications is hereby revised for this project to include the following:

Epoxy Pavement Marking shall have uniform mil thickness and bead distribution across the entire width of the line. Unless otherwise shown on the plans, typical pavement markings shall conform to the shapes and sizes as shown on Standard Plan S-627-1. Any marking that does not meet specification shall be removed and replaced at the contractor's expense.

Subsection 627.05, Delete the seventh and eighth paragraphs, and replace with the following:

Epoxy pavement marking shall be applied to the road surface according to the epoxy manufacturer's recommended methods at a range from 16 - 18 mils minimum thickness. Glass beads shall be applied into the epoxy pavement marking by means of a low pressure, gravity drop bead applicator. The bead applicator shall disperse the glass beads using a 360 degree dispersion pattern and a 360 degree shroud for the specified width of longitudinal pavement marking.

Epoxy pavement marking and beads shall be applied within the following limits:

**Application Rate or Coverage
Per Gallon of Epoxy Pavement Marking**

	Minimum	Maximum
16 - 18 mil marking	90 sq. ft.	100 sq. ft.
Beads	22 lbs.	As Needed

**REVISION OF SECTION 627 AND 713
EPOXY PAVEMENT MARKING (SPECIAL)**

Section 627 is hereby revised for this project as follows:

CONSTRUCTION REQUIREMENTS

Section 627.05 of the Standard Specifications shall include the following:

- (a) Epoxy Pavement Marking (Special) shall be applied to the road surface according to the epoxy manufacturer's recommended methods at 22 mils ± 2 mils minimum thickness.

The surface area receiving marking shall be ground prior to placement of the Epoxy Pavement Marking (Special). This applies to new or existing concrete or asphalt pavements. Grinding of the pavement is required so that Epoxy Pavement Marking (Special) is inlaid. The ground surface shall be cleaned with a high pressure air blast to remove loose material prior to placement of the Epoxy Pavement Marking (Special). The grooved width for inlaid pavement marking shall be a max width of 4 ¼ inch and a min width of 4 inch. The depth of the inlaid grooves shall be 100 mils below the surface of the existing pavement. Groove position shall be a minimum of 4 inches from the edge of the pavement marking to the longitudinal pavement joint. The Contractor shall set the spacer width between blades such that there is less than a 5 mil rise in the pavement between the blade grooves.

Grooves shall be clean, dry and free of laitance, oil, dirt, grease, paint or other foreign contaminants. The Contractor shall prevent traffic from traversing the grooves, and shall re-clean grooves, as necessary, prior to application of the preformed plastic pavement markings.

The Contractor shall not perform more inlaid grinds than can be applied by the pavement marking truck during the same working day or working period. Unless approved by the Engineer.

If a rain event occurs during grinding and marking application, temporary raised flexible pavement markers shall be installed on all channelizing, center, and lane lines. Temporary markers shall also be placed on edge lines where lighted curb or other delineation is not provided as directed by the engineer. The frequency of temporary markers shall be according to Section 6F.79 of MUTCD. Marking application may proceed only when pavement is dry and has had no moisture for a minimum of 24 hours.

- (b) *Bead System.* There shall be two types of ceramic beads used for the Epoxy pavement marking (Special) reflective elements, a Primary bead which is a high performance, high reflective all weather bead and a Secondary standard glass bead. The beads shall be applied using a double drop system with the Primary bead dropped first. The beads shall be applied in a manner that the beads shall adhere and embed within the Epoxy binder to produce a high reflective all weather pavement marking.

The primary and secondary beads shall be applied to the Epoxy binder based on the manufacturers recommended application rate. The Primary composite, cluster, bonded core beads shall be applied first from the bead dispenser directly behind the Epoxy binder application gun followed immediately by the application of the Secondary beads from a

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**REVISION OF SECTION 627 AND 713
 EPOXY PAVEMENT MARKING (SPECIAL)**

second bead dispenser. If the manufacturer does not provide application rates of the primary and secondary beads, then the following application rates for each of the glass beads shall be used as a starting point: 11 lbs per gallon of Primary composite beads and 7 lbs per gallon of the Secondary beads. The application rates of the primary and secondary beads shall be adjusted from these starting values until the minimum reflectivity values have been consistently achieved.

Primary and Secondary glass beads shall be furnished in fully identified separate containers and shall be free of extraneous materials or clumps.

1) Retro reflectivity. The applied finish system must have an initial minimum dry reflectivity reading of 800 mcd-m-2·1x-1 for white and 500 mcd-m-2·1x-1 for yellow. The Contractor shall use an industry accepted and available Retro-meter for reflectivity readings and it shall be calibrated each day testing occurs. For information: (CDOT will be using a Delta LTL-X Retro-meter for reflectivity readings). Contractor shall provide reflectivity readings from the Contractor for each mile of line placed or fraction thereof. CDOT will determine 4 random testing locations for each 1 mile section of line placed or fraction thereof. At each random testing location three reflectivity readings will be taken on each line. Of the 12 readings per mile the highest and lowest will be disregarded and the remaining 10 readings will be averaged and that average value will represent the reflectivity of that 1 mile section or fraction of line thereof. The contractor shall remove and replace at their expense each 1 mile of line placed or fraction thereof where the test result from that random location fails the minimum retro reflectivity reading.

The reflectivity readings shall be taken no sooner than 1 hour after the marking is tack free and no later than 2 hours after the marking is tack free. Lane closure and traffic control used for the marking placement shall remain until after the reflectivity readings are taken. Traffic should not be allowed on the marking until after the reflectivity readings are taken. Prior to taking reflectivity readings, the Contractor shall remove at the reflectivity reading locations any excess beads placed during marking application.

Applied markings shall have uniform mil thickness and bead distribution across the entire width of the line. Unless otherwise shown on the plans, typical pavement markings shall conform to the shapes and sizes as shown on Standard Plan S-627-1. Any marking that does not meet specification shall be removed and replaced at the contractor's expense.

Epoxy Pavement Marking (Special) and beads shall be applied within the following limits:

**Application Rate or Coverage
 Per Gallon of Epoxy Pavement Marking**

	Minimum	Maximum
20 - 24 mil marking	65 sq. ft.	80 sq. ft.
Beads	16 lbs.	As Needed

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**REVISION OF SECTION 627 AND 713
EPOXY PAVEMENT MARKING (SPECIAL)**

Section 713.08 of the Standard Specifications shall include the following:

Subsection 713.08 shall include the following:

Primary glass beads for epoxy pavement marking (special) shall be a composite, cluster, bonded core bead comprised of a core element and contain an outer shell containing elements surrounding it. The shell elements shall be permanently attached to the core element. The core and shell elements shall be manufactured from glass, ceramic, or silica. The primary element shall be coated by manufacturer's recommendations for application within Epoxy binder.

If the use of recycled post-consumer glass is used in manufacturing of beads those recycled glass beads shall be manufactured from North American glass waste streams.

Secondary glass beads for epoxy pavement marking (special) shall be glass beads for epoxy pavement marking as specified elsewhere in subsection 713.08.

**REVISION OF SECTION 627 AND 713
PERFORMED THERMOPLASTIC PAVEMENT MARKING (IN-LAID)**

Section 627 and 713 of the Standard Specifications is hereby revised for this project as follows:

Subsection 627.09 shall include the following:

Depth of inlaying below the existing asphalt surface shall be a minimum of 60 mils. Grinding or inlaying of existing preformed thermoplastic pavement marking shall not be measured and paid for separately, but shall be included in the work.

An epoxy resin primer shall be applied to all existing surfaces (concrete, asphalt, existing markings, etc.) prior to the application of any new preformed thermoplastic, plastic pavement marking. The epoxy resin primer shall conform to CDOT Standard Specifications subsection 708.07. Primer shall be required for all markings used including markings that manufacture does not require a primer. Primer and application will not be measured and paid for separately, but shall be included in the work.

Surface shall be dry and free of dirt, dust, chemicals, and/or significant oily substances. Application procedures for Portland concrete pavement shall be as described above except a compatible primer sealer shall be applied before application of marking to assure proper adhesion.

Subsection 713.14 shall include the following:

(a) *General.*

Material such as lines, legends, or symbols shall be capable of being affixed to HMA or PCC pavements. Marking shall be capable of conforming to pavement contours, breaks, and faults etc. by the use of the normal heat of a propane torch. Marking shall be capable of withstanding the actions of traffic at normal pavement temperatures. Marking shall have resealing characteristics such that it is capable of fusing with itself and previously applied thermoplastic pavement markings when heated with the torch.

(b) *Physical Requirements.*

1. Marking shall have a factory applied coated surface of beads in addition to the intermixed beads at the rate of 1 lb. (\pm 10%) per 11 sq. ft. The factory applied coated surface beads shall have the following specifications:

- a) Minimum 80% round
- b) Minimum refractive index of 1.50.
- c) Minimum SiO₂ content of 70%
- d) Maximum iron content of 0.1%
- e)

Size Gradation	% Retained
14	0-3%
16	2-10%
18	10-30%
20	30-60%
30	50-80%
35	60-85%
45	95-100%
60	98-100%

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**REVISION OF SECTION 627 AND 713
PREFORMED THERMOPLASTIC PAVEMENT MARKING**

(c) *Performance.*

Marking, when applied in accordance with manufactures recommendations shall demonstrate a uniform level of sufficient night time retro-reflection when tested in accordance to ASTM E1710-97. The applied material must have an initial minimum intensity reading of $500 \text{ mcd}\cdot\text{m}^{-2}\cdot 1\text{x}^{-1}$ for white and $300 \text{ mcd}\cdot\text{m}^{-2}\cdot 1\text{x}^{-1}$ for yellow as measured with a retro-reflectometer.

The top surface of the stencils (the same side as the factory applied surface beads) shall have an indicator system for the contractor to properly gauge the correct amount of heat to apply during installation. The indicator system shall have a positive visual indication, such as beads changing color or indents closing together, when the material has reached the correct installation temperature. The indicator system must also provide a positive, visual indication if the material has not reached the correct installation temperature.

FORCE ACCOUNT ITEMS

DESCRIPTION

This special provision contains the Department's estimate for force account items included in the Contract. The estimated amounts marked with an asterisk will be added to the total bid to determine the amount of the performance and payment bonds. Force Account work shall be performed as directed by the Engineer.

BASIS OF PAYMENT

Payment will be made in accordance with subsection 109.04. Payment will constitute full compensation for all work necessary to complete the item. Force Account Items include both Bridge Enterprise and Non-Bridge Enterprise work.

Force account work valued at \$5,000 or less, that must be performed by a licensed journeyman in order to comply with federal, state, or local codes, may be paid for after receipt of an itemized statement endorsed by the Contractor.

<u>Force Account Item</u>	<u>Quantity</u>
F/A Minor Contract Revisions	F A
F/A Partnering	F A
F/A Fuel Cost Adjustment	F A
F/A Asphalt Cement Cost Adjustment	F A
F/A On-The-Job Trainee	Hour
F/A Hazardous Materials Mitigation	F A
F/A DRB Standing Committee	F A
F/A Railroad Utilities	F A
F/A OCIP Incentive Payment	F A

The Estimated Dollar Amount will be determined by the Region Materials Engineer and the Project Engineer.