



State of Georgia

Supplemental Specifications Modifying
the
2013 Standard Specifications
Construction of
Transportation Systems

2016 Edition

2016 Edition
Supplemental Specifications
Construction of
Transportation Systems



Modifying the Standard Specifications, 2013 Edition
Approved by the State Transportation Board
on June 16, 2016

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The Standard Specifications for the Construction of Transportation Systems, dated April 18, 2013 shall be modified and expanded in accordance with the revisions, deletions, and additions contained herein.

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2013 Standard Specifications Editorial and Errata Corrections

Page	Section	Correction
267	400.1.02.B	Add "AASHTO T-331".
306	402.2.E	In the second paragraph, first sentence – Delete "(600 to 1600 PA)" And add "(6.0 to 16.0 kPa)".
1178	834.2.01.A.3	In the first sentence - Delete "AASHTO M 91" And add "ASTM C 32".
1324	894.2.06.A.1.2a	In the second sentence – Delete "a T-90" And add " T-90 or T-45".

Section 107 – Legal Regulations and Responsibility to the Public

Delete Section 107 and Substitute the following:

107.01 Laws to Be Observed

The Contractor shall keep fully informed of all Federal and State laws, all local laws, ordinances, codes, and regulations and all orders and decrees of bodies or tribunals having any jurisdiction or authority, which in any manner affect those engaged or employed on The Work, or which in any way affect the conduct of The Work. The Contractor shall at all times observe and comply with all such laws, ordinances, codes, regulations, orders, decrees, and permits; and shall protect and indemnify the Department and its representatives against any claim or liability arising from or based on the violation of any such law, ordinance, code, regulation, order, decrees, and permits, whether by himself, his employees, subcontractors, or agents.

107.02 Permits and Licenses

The Contractor shall procure all permits and licenses, pay all charges, taxes, and fees, and give all notices necessary and incidental to the due and lawful prosecution of The Work.

107.03 Patented Devices

If the Contractor employs any design, device, material, or process covered by letters of patent or copyright, he shall provide for such use by suitable legal agreement with the patentee or owner. The Contractor and the Surety shall indemnify and save harmless the Department from any and all claims for infringement by reason of the use of any such patented design, device, material, or process, or any trademark or copyright, and shall indemnify the Department for any costs, expenses, and damages which it may be obliged to pay by reason of any infringement, at any time during the prosecution or after the completion of The Work.

107.04 Restoration of Surfaces Opened By Permit

The right to construct or reconstruct any utility service in the highway or street and to grant permits for the same at any time, is expressly reserved by the Department for the proper authorities of the municipality or county in which The Work is done and the Contractor shall not be entitled to any damages either for the digging up of the street or highway, or for any delay occasioned thereby.

Any individual, firm, or corporation wishing to make an opening in the street or highway must secure a permit from the Department. The Contractor shall allow parties bearing such permits, and only those parties, to make openings in the street or highway. When ordered by the Engineer, the Contractor shall make in an acceptable manner all necessary repairs due to such openings and such necessary work will be paid for as Extra Work, or as provided in the Specifications, and will be subject to the same conditions as original work performed.

107.05 Federal-Aid Provisions

When the United States Government pays all or any part of the cost of a project, the Federal laws and the rules and regulations made pursuant to such laws must be observed by the Contractor, and The Work shall be subject to the inspection of the appropriate Federal agency. Such inspection shall in no sense make the Federal Government a party to this Contract and will in no way interfere with the rights of either party hereunder.

107.06 Sanitary Provisions

The Contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of his employees as may be necessary to comply with the requirements of the State Department of Health and other authorities having jurisdiction, and shall permit no public nuisance.

107.07 Public Convenience and Safety

The Contractor shall at all times so conduct The Work as to assure the least possible obstruction of traffic. The safety and convenience of the general public and the residents along the highway and the protection of persons and property shall be provided for by the Contractor as specified under Subsection 104.05, Subsection 107.09, Section 150, the Project Plans, and Special Provisions.

Traffic whose origin and destination is within the limits of the Project shall be provided ingress and egress at all times unless otherwise specified in the Plans or Special Provisions. The ingress and egress includes entrance and exit via driveways at the various properties, and access to the intersecting roads and streets. The Contractor shall maintain sufficient personnel and equipment on the project at all times, particularly during inclement weather, to ensure that ingress and egress are provided when and where needed.

Two-way traffic shall be maintained at all times unless otherwise specified or approved. The Contractor shall not stop traffic without permission granted by the Engineer.

All equipment used on The Work shall come equipped with factory-installed mufflers, or manufacturer's recommended equivalent, in good condition. These mufflers shall be maintained in good condition throughout the construction period.

107.08 Railroad-Highway Provisions

All work to be performed by the Contractor on a railroad company's right-of-way or property shall be done in a manner satisfactory to the chief engineer of the railroad company, or his authorized representative, and shall be performed at such times and in such manner as not to unnecessarily interfere with the movement of trains or traffic upon the track of the railroad company. The Contractor shall use all reasonable care and precaution in order to avoid accidents, damage, or unnecessary delay or interference with the railroad company's trains or other property, or property of tenants of railroad company.

The Contractor shall notify the railroad company and obtain its approval before commencing work on the railroad company's right-of-way or property.

The Contractor shall determine what measures are required by the railroad company to protect its operations and right-of-way or property during construction. Such protection may include the use of a flagger or flaggers provided by the railroad company. The Contractor shall be responsible for ensuring that the required protection is provided and shall pay the railroad company directly for any and all such services which may be required to accomplish the construction unless otherwise specified.

Any temporary grade crossings or other means needed during construction by the Contractor for transporting materials of any nature and/or equipment across the railroad tracks will be the responsibility of the Contractor to handle directly with the railroad company and bear all costs incidental to such crossings including flagging services provided by the railroad company.

A "Special Provisions for the Protection of Railroad Interests" may be included in the proposal to stipulate insurance and other requirements of the railroad company.

107.09 Barricades and Danger, Warning, and Detour Signs

The Contractor shall furnish, install, and maintain all necessary and required barricades, signs, and other traffic control devices in accordance with these Specifications, Project Plans, Special Provisions, and the MUTCD, and take all necessary precautions for the protection of the work and safety of the public.

Unless otherwise specified, all traffic control devices furnished by the Contractor shall remain the property of the Contractor.

107.10 Forest Protection

In carrying out work within or adjacent to State or National Forests, or any other forests, parks, or other public or private lands, the Contractor shall obtain necessary permits and comply with all of the regulations of the appropriate authorities having jurisdiction over such forest, park, or lands. The Contractor shall keep the areas in an orderly condition, dispose of all refuse, obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks, and other structures in accordance with the requirements of the appropriate authority.

The Contractor shall take all reasonable precautions to prevent and suppress forest fires and shall require his employees and subcontractors, both independently and at the request of forest officials, to do all reasonably within their power to prevent and suppress and to assist in preventing and suppressing forest fires; to notify a forest official at the earliest possible moment of the location and extent of any fire seen by them; and to extinguish or aid in extinguishing nearby fires.

107.11 Construction Over or Adjacent to Navigable Waters

A. Navigation to Be Protected

Since navigable waterways are under the jurisdiction of the United States Coast Guard and/or the United States Army Corps of Engineers, all work done in, over, on or adjacent to such waters shall comply with their requirements. Free navigation shall not be impeded, and navigable depths shall be maintained.

The Contractor shall comply with permits issued by the United States Coast Guard and/or the United States Army Corps of Engineers, and the Contractor shall obtain and comply with other permits in accordance with the requirements of Subsection 107.02

Special Provisions for environmental protection may be included in the proposal to stipulate environmental commitments and other requirements.

B. Obstructions to be Removed

When the construction has progressed enough to permit removal, all falsework, piling and other obstructions shall be removed to the satisfaction of the Federal agency having jurisdiction. In all cases such clearing must be done thoroughly before The Work will be accepted by the Department.

107.12 Use of Explosives

When the use of explosives is necessary for the prosecution of The Work, the Contractor shall exercise the utmost care not to endanger life or property, and shall obey all State, Federal and other Governmental regulations applying to transportation, storage, use, and control of such explosives. The Contractor shall be completely responsible for any and all damage resulting from the transportation, storage, use, and control of explosives in the prosecution of The Work by the Contractor, the Contractor's agents, or employees; and shall hold the Department harmless from all claims of damages resulting in any manner therefrom.

The Contractor shall notify each public utility owner having structures or other installations, above or below ground, near the site of The Work of his intention to use explosives. Such notice shall be given sufficiently in advance to enable the utility owners to take such steps as they may deem necessary to protect their property from injury. Such notice shall not relieve the Contractor of responsibility for all damages resulting from his blasting operations.

All explosives shall be stored securely in compliance with all laws and ordinances, and all such storage places shall be clearly marked DANGEROUS EXPLOSIVES. Explosives and detonators shall be stored in separate storage facilities in separate areas. Where no laws or ordinances apply, locked storage shall be provided satisfactory to the Engineer, never closer than 1,000 ft (300 m) from any travel-road, building, or camping area.

In all cases where the transport, storage, or use of explosives is undertaken, such activities shall be controlled and directed by fully qualified representatives of the Contractor.

Whenever electric detonators are used, all radio transmitters shall be turned off within a radius of 500 ft (150 m). No blasting supplies shall be transported in vehicles with two-way radio unless the transmitter is turned off, or extra shielding precautions are taken. Appropriate signs shall be placed so as to give ample warning to anyone driving a vehicle equipped with two-way radio. Electrical detonators will not be used within 500 ft (150 m) of a railroad.

Submit a blasting plan to the Engineer a minimum of five working days prior to use of explosives that provides details of the proposed blasting plan, including, but not limited to, the type and amount of explosives, the shot sequence, the description of and distance to the closest inhabitable structure, and other information as requested by the Engineer. Submission of blasting plan does not relieve the contractor of the responsibility for the adequate and safe performance of the blasting.

107.13 Protection and Restoration of Property and Landscape

A. General Provisions

The Contractor shall be responsible for the preservation of all public and private property, crops, fish ponds, trees, monuments, highway signs and markers, fences, grassed and sodded areas, etc. along and adjacent to the highway, and shall use every precaution necessary to prevent damage or injury thereto, unless the removal, alteration, or destruction of such property is provided for under the Contract. The Contractor shall use suitable precaution to prevent damage to all underground structures, whether shown on the Plans or not, and shall protect carefully from disturbance or damage, all land monuments and property marks until the Engineer has witnessed or otherwise referenced their location and shall not move them until directed. The Contractor shall not willfully or maliciously injure or destroy trees or shrubs, and he shall not remove or cut them without proper authority.

The Contractor shall be responsible for all sheet piling, shoring, underpinning, etc., as may be required for the protection of abutting property, nearby buildings, streets, and the like.

The Contractor shall be responsible for all damage or injury to property of any character, during the prosecution of The Work, resulting from any act, omission, neglect, or misconduct in his manner or method of executing The Work, or at any time due to defective work or materials, and said responsibility will not be released until the Project shall have been completed and accepted.

When the Contractor's excavating operations encounter remains of prehistoric people's dwelling sites or artifacts of historical or archeological significance, the operations shall be temporarily discontinued. The Engineer will contact archeological authorities and the Office of Environmental Services to determine the disposition thereof. When directed by the Engineer, the Contractor shall excavate the site in such a manner as to preserve the artifacts encountered and shall remove them for delivery to the custody of the proper authorities. Such excavation will be considered and paid for as Extra Work.

When the Contractor's normal operations are delayed by such stoppage or extra work, an appropriate time extension will be granted.

The Contractor shall plan, coordinate, and prosecute the work so that disruption to personal property and business is held to a practical minimum.

No resident or business shall be denied vehicular access to their property for any length of time other than as determined by the Engineer is absolutely necessary. Where two or more existing driveways are present for a business, only one existing driveway shall be closed at any time. All construction areas abutting lawns and yards of residential or commercial property shall be restored promptly. Backfilling of each drainage structure or section of curb and gutter, sidewalk, or driveway shall be accomplished as soon as adequate strength is obtained. Finishing, dressing, and grassing shall be accomplished immediately thereafter as a continuous operation within each area being constructed with emphasis placed on completing each individual yard or business frontage. Care shall be taken to provide positive drainage to avoid ponding or concentration of runoff.

Handwork, including raking and smoothing, shall be required to ensure that roots, sticks, rocks, and other debris are removed in order to provide a neat and pleasing appearance. Grassing, when in season, shall immediately follow in order to establish permanent cover at the earliest date. If grassing is not in season, proper erosion control shall be installed and maintained.

The work described above shall be in addition to that required by Subsection 104.07, "Final Cleaning Up" and Subsection 105.16, "Final Inspection and Acceptance".

B. Erosion and Siltation Control

The Contractor shall take all necessary measures throughout the life of the Project to control erosion and silting of rivers, streams, and impoundments (lakes, reservoirs, etc.). Construction of drainage facilities as well as performance of other Contract work which will contribute to the control of erosion and siltation shall be carried out in conjunction with clearing and grubbing, and earthwork operations as stipulated in Section 161.

C. Pollution

The Contractor shall exercise every reasonable precaution throughout the life of the Contract to prevent pollution of rivers, streams or impoundments. Pollutants such as chemicals, fuels, lubricants, bitumens, raw

sewage and other harmful waste shall not be discharged into or alongside rivers, streams, and impoundments, or into natural or manmade channels leading thereto. The Contractor shall also comply with the applicable regulations of other State and Federal departments and to all governmental statutes relating to the prevention and abatement of pollution.

D. Insect Control Regulations

The Plant Pest Control Division of the U.S. Department of Agriculture and the Georgia State Department of Agriculture restrict the movement of certain items from areas infested with Japanese Beetles or Imported Fire Ants so as to prevent the spread of these pests to non-infested areas. Where insect infested areas are shown on the Plans, Contractors will control their operations in such a manner as to comply fully with the requirements of Section 155.

E. Reclamation of Material Pits and Waste Disposal Areas

Whenever or wherever the Contractor obtains material from a source or wastes material on an area other than within the Right-of-Way, regardless of the fashion, manner or circumstances for which the source or area is obtained, it shall be reclaimed in accordance with the requirements of Section 160.

F. Mailboxes

The property owner shall have the responsibility for removing and relocating the mailbox to an area outside construction limits.

The Engineer will mark a point for the relocation of the box. The stake should be set so that the location of the box will be convenient to both the mail carrier and the patron, yet not interfering with the proposed work. It may be necessary for the Engineer to confer with the Post Office serving the area.

The Contractor shall notify each affected owner, in writing, that their mailbox is in conflict with the proposed construction, that they have ten days to relocate the box and that, after the expiration of the 10 days' notice, if the owner has not relocated the box, it shall be removed by the Contractor and laid upon the owner's property, clear of the Right-of-Way.

Any cost to the Contractor for removing the mailboxes as stated above shall be included in the price bid for other items.

G. Failure to Comply

Failure of the Contractor to comply with any of the above provisions or to install erosion prevention items included in the Contract at the time specified, will be evidence of omission and neglect, and the Contractor will be liable for damages as outlined in Subsection 107.13.H below. Furthermore, the Engineer shall withhold payment on all Contract Items until such time as the Contractor complies in full with all of the aforesaid provisions.

H. Payment for Damages

When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the Work, or in consequence of the nonexecution thereof by the Contractor, the Contractor shall restore, at his own expense, such property to a condition similar or equal to that existing before such damage or injury was done, by repairing, rebuilding or otherwise restoring as may be directed, or shall make good such damage or injury in an acceptable manner.

I. Compensation

All costs pertaining to any requirement contained herein shall be included in the overall Bid submitted unless such requirement is designated as a separate Pay Item in the Proposal.

107.14 Load Restrictions

It is hereby agreed between the Department and the Contractor that in the performance of The Work under the Contract, the following load restrictions and stipulations shall be in full force and effect during the life of the Contract:

A. Parties Affected

The load restrictions and stipulations contained herein shall be applicable to the equipment of the Contractor; each agent or subcontractor employed by the Contractor; and each person or persons, firm, partnership, corporation or any combination thereof, hauling materials, supplies or equipment to or on the Project, by or for the Contractor.

B. Within Project Limits

No hauling equipment which is loaded beyond those limits provided by State Law shall be permitted on any portion of the new or existing pavement structure except that such loads will be permitted on nonstabilized bases and subbases prior to placing roadway paving subject to the provisions of Subsection 107.17.

Axle loads and gross weight limits will be evaluated in accordance with current Georgia Law.

All damage caused by any equipment to any permanent installation or portion of The Work shall be promptly repaired by the Contractor at his expense. When it becomes necessary to cross existing pavement with excessive loads, the Contractor shall provide and remove, at his own expense, proper cushioning by means of earth blanket or otherwise as directed.

C. Outside Project Limits

All equipment users included in Subsection 107.14.A, above, operating equipment on roads outside the Project limits shall be governed by the following regulations:

1. No vehicle shall carry any load in excess of that specified by Georgia Law.
2. On County System roads the maximum total gross weight shall not exceed 56,000 lbs. (25,400 kg) unless a vehicle is making a pickup or delivery on such roads.
3. For a specific individual trip the above weight limitations may be exceeded provided a special permit is obtained from the Department for each such movement. A special permit will not relieve the Contractor of liability for damage that may result from such a movement. Refer to O.C.G.A §32-6-26 Weight of Vehicle and Load, SB54 (2011) for compliance with weight limitations and exceptions.
4. Authorized personnel of the Department of Public Safety shall be permitted to weigh each truck hauling material to the Project whenever the Department so desires. The owner of each truck shall instruct his operators to cooperate with and assist the truck weighers in every way possible.
5. A Certified Public Weigher operating under the provisions of Standard Operating Procedure 15 shall not dispatch any vehicle loaded with material to be incorporated into the Project when the gross vehicle weight exceeds the limit established by law.
6. Ready Mix Concrete trucks shall comply with load restrictions as specified in Laboratory Standard Operating Procedure 10, "Quality Assurance for Ready-Mixed Concrete Plants in Georgia."

D. Responsibilities

It will be the responsibility of the Contractor to advise his personnel, and all equipment users included in Subsection 107.14.A, as to the load restrictions and stipulations contained herein.

E. Excess Loads and Violations

If multiple violations assignable to a given Certified Public Weigher are occurring, that Certified Public Weigher may be suspended from weighing materials dispatched to Department of Transportation projects.

107.15 Responsibility for Damage Claims

The Contractor shall indemnify and save harmless the Department, its officers and employees, from all suits, actions, or claims of any character brought because of any injuries or damage received or sustained by any person, persons, or property on account of the operations of the said Contractor; or on account of or in consequence of any neglect in safe-guarding The Work; or through use of unacceptable materials in constructing The Work; or because of any act of omission, neglect or misconduct of said Contractor; or because of any claims or amounts recovered from any infringements of patent, trademark, or copyright; or from any claims or amounts arising or recovered under the Workmen's Compensation Act, or any other law, ordinance, order, or decree; and so much of the money due the

said Contractor under and by virtue of his Contract as may be considered necessary by the Department for such purpose may be withheld for the use of the State; or, in case no money is due, his surety may be held until such suit or suits, action or actions, claim or claims for injuries or damages as aforesaid shall have been settled and suitable evidence to that effect furnished to the Department; except that money due the Contractor will not be withheld when the Contractor produces satisfactory evidence that he is adequately protected by public liability and property damage insurance.

107.16 Opening Sections of Project to Traffic

Whenever any bridge or section of roadway is in acceptable condition for travel, the Engineer may direct that it be opened to traffic, whether or not the opening was originally provided for, and such opening shall not be held to be in any way an acceptance of the bridge or roadway, or any part thereof, or as a waiver of any of the provisions of the Contract. Necessary repairs or renewals made on any section of the roadway or bridge thus opened to traffic under instructions from the Engineer, due to defective material or work, or to any cause other than ordinary wear and tear, pending completion and acceptance of the roadway, bridge, or other work, shall be done by the Contractor, without additional compensation. Also, the Contractor shall not receive additional compensation for completing the Work except as specified in Subsection 104.03.

If the Contractor is dilatory in completing shoulders, drainage structures, or other features of work, the Engineer may so notify him in writing and establish therein a reasonable period of time in which the Work should be completed. If the Contractor is dilatory, or fails to make a reasonable effort toward completion in this period of time, the Engineer may then order all or a portion of the Project opened to traffic. On such sections which are so ordered to be opened, the Contractor shall conduct the remainder of his construction operations so as to cause the least obstruction to traffic and shall not receive any added compensation due to the added cost of the Work by reason of opening such section to traffic.

On any section opened to traffic under any of the above conditions, whether stated in the Special Provisions or opened by necessity of Contractor's operations, or unforeseen necessity, any damage to the highway not attributable to traffic which might occur on such section (except slides) shall be repaired by the Contractor at his expense. The removal of slides shall be done by the Contractor on a basis agreed to prior to the removal of such slides.

107.17 Contractor's Responsibility for the Work

From the first day the Contractor begins work, or from the date Contract Time commences, whichever occurs first, until written final acceptance of the project by the Engineer, the Contractor shall have the charge and care thereof and shall take every precaution against injury or damage to any part thereof by the action of the elements or from any other cause, whether arising from the execution or from the non-execution of The Work. The Contractor shall rebuild, repair, restore, and make good all injuries or damages to any portion of The Work occasioned by any of the above causes before final acceptance and shall bear the expense thereof except that the Department may, in its discretion, reimburse the Contractor for the repair of damage to The Work due to unforeseeable causes beyond the control of and without the fault or negligence of the Contractor, including but not restricted to acts of God, of the public enemy or of governmental authorities. The Contractor's responsibility for damages and injuries is defined in Subsection 104.05.A.

In case of suspension of work from any cause whatsoever, the Contractor shall be responsible for the Project and shall take such precautions as may be necessary to prevent damage to the Project, provide for normal drainage and shall erect any necessary temporary structures, signs, or other facilities at his expense.

107.18 Acquisition of Right-of-Way

Rights of Way for the project will be obtained by the Department, in coordination with local governments and others. However, the Contractor's access to the portions of the right-of-way may be restricted. Where such restrictions are known in advance to the Department they will be listed in the bid proposal. Delays to the progress of the Work may be encountered because of restricted access to portions of the right-of-way. When such delays occur, whether caused by restrictions listed in the bid proposal or restrictions that develop after the Contract is signed, the parties agree in executing the Contract that such delays do not constitute breach of the Contract. Delays in availability of right-of-way beyond those listed in the bid proposal, or that develop after the Contract has been signed, that impact the controlling Item or Items of the Work will not be charged against the Contract Time. Additional compensation for such delays shall not be paid, except as provided in Subsection 105.13, "Claims for Adjustments and Disputes," or Subsection 109.09, "Termination Clause." In the event the Department is unable to

acquire right-of-way needed for the project, resulting in delay to or termination of the project, such situation will also be controlled by this Section, and will not constitute a breach of the Contract by the Department.

107.19 Personal Liability of Public Officials

In carrying out any of the provisions of the Contract or in exercising any power or authority granted to the Board, Commissioner, Chief Engineer, their agents and employees, by the Contract, there shall be no liability, either personally or as officials or representatives of the Department, it being understood that in all such matters they act solely as agents and representatives of the Department.

107.20 No Waiver of Legal Rights

Upon completion of The Work, the Department will expeditiously make final inspection and notify the Contractor of acceptance. Such final acceptance, however, shall not preclude or estop the Department from correcting any measurement, estimate, or certificate made before or after completion of The Work, nor shall the Department be precluded or estopped from recovering from the Contractor or his Surety, or both, such over-payment as it may sustain, or by failure on the part of the Contractor to fulfill his obligations under the Contract. A waiver on the part of the Department of any breach of any part of the Contract shall not be held to be a waiver of any other or subsequent breach.

The Contractor, without prejudice to the terms of the Contract, shall be liable to the Department for latent defects, fraud, or such gross mistakes as may amount to fraud, or as regards the Department's rights under any warranty or guaranty.

107.21 General Description

The Contractor shall designate, prior to beginning any work, a Worksite Utility Coordination Supervisor (WUCS) who shall be responsible for initiating and conducting utility coordination meetings and accurately recording and reporting the progress of utility relocations and adjustment work. Also, the WUCS shall prepare an Emergency Response Plan for the purpose of planning, training, and communicating among the agencies responding to the emergency. The WUCS shall be the primary point of contact between all of the Utility companies, the Contractor and the Department. The WUCS shall recommend the rate of reoccurrence for utility coordination meetings and the Engineer will have the final decision on the regularity for utility coordination meetings. In no case will utility coordination meetings occur less than monthly until controlling items of utility relocations and adjustment milestones are completed. The WUCS shall contact each of the utility companies for the purpose of obtaining information including, but not limited to, a Utility Adjustment Schedule for the controlling items of utility relocations and adjustments. The WUCS shall notify the appropriate utility company and/or utility subcontractors and the Department of the status of controlling items of relocations and adjustment milestones as they are completed. The WUCS shall furnish the Engineer, for approval, a Progress Schedule Chart, immediately following the receipt of the Notice to Proceed unless otherwise specified, which includes the utility companies controlling items of work and other information in accordance with Section 108.03 or elsewhere in the Contract documents.

A. Qualifications

The WUCS shall be an employee of the Prime Contractor, shall have at least one year experience directly related to highway and utility construction in a supervisory capacity and have a complete understanding of the Georgia Utilities Protection Center operations, and shall be knowledgeable of the High-voltage Safety Act and shall be trained on the Georgia Utility Facility Protection Act (GUFPA). The Department does not provide any training on GUFPA but will maintain a list of the Georgia Public Service Commission certified training programs developed by other agencies. Currently the following companies offer approved GUFPA training programs:

Associated Damage Consultants
Phone: 706.234.8218 or 706.853.1362
Georgia Utility Contractors Association
Phone: 404.362.9995

Georgia Utilities Protection Center
Phone: 678.291.0631 or 404.375.6209
H B Training & Consulting
Phone: 706.619.1669 or 877.442.4282 (Toll Free)

The Prime Contractor is responsible for obtaining the GUFPA training for their employees. Questions concerning the Georgia Public Service Commission GUFPA training program should be directed to:
Georgia Public Service Commission
244 Washington St. SW
Atlanta, GA 30334-5701
404.463.9784

B. Ticket Status

During the utility coordination meetings the WUCS shall collect and maintain the Ticket Status information to determine the status of all locate requests within the project limits. This information will be used to assure those planning to use mechanized equipment to excavate or work within the project limits are prepared to begin work when they have reported or estimated beginning work. At points where the Contractor's or utility company's operations are adjacent to or conflict with overhead or underground utility facilities, or are adjacent to other property, damage to which might result in considerable expense, loss, or inconvenience, work shall not commence until all arrangements necessary for the protection thereof have been made.

C. Notice

The names of known utility companies and the location of known utility facilities will be shown on the Plans, or listed in the Subsurface Utility Engineering Investigation if performed or in the Special Provisions; and the WUCS shall give 24-hour notice to such utility companies before commencing work adjacent to said utility facilities which may result in damage thereto. The WUCS shall further notify utility companies of any changes in the Contractor's work schedules affecting required action by the utility company to protect or adjust their facilities. Notice to the utility companies by the Department of the Award of Contract, under Subsection 105.06, shall not be deemed to satisfy the notice required by this paragraph. Furthermore, this 24-hour notice shall not satisfy or fulfill the requirements of the Contractor as stated in Chapter 9 of Title 25 of the Official Code of Georgia Annotated, known as the "Georgia Utility Facility Protection Act".

D. Agenda

The WUCS shall cooperate with the companies of any underground or overhead utility facilities in their removal and relocations or adjustment work in order that these operations may progress in a reasonable manner, that duplication of their removal and relocations or adjustment work may be reduced to a minimum, and services rendered by those parties will not be unnecessarily interrupted. To promote this effort the WUCS shall prepare an agenda for the utility coordination meetings and circulate same in advance of the meeting to encourage input and participation from all of the utility companies. The agenda will be prepared by an examination of the project site and may include photographs of potential/actual utility conflicts.

E. Emergency Response Plan

The WUCS shall prepare an Emergency Utility Response Plan (EURP) within 30 days following the receipt of the Notice to Proceed. The EURP shall indicate the project location (which includes street address and or major intersections / major highway route, if possible with a land mark) that would be reported in case of an emergency, WUCS, Emergency Utility Coordinator (EUC), utility company name, utility company emergency contact information to include but not limited to emergency phone number, response time for emergency, working condition of devices needed to facilitate prompt shut off, and primary point of contact name and phone number for the project.

Emergency Utility Coordinator (EUC) shall be an employee of the Prime Contractor and shall notify the appropriate utility company and/or utility subcontractors in case of an emergency. EURP must include the contact details of the EUC, if WUCS is not the primary emergency utility coordinator for this project.

The plan will also include a means of reporting emergencies and the Utility Emergency Response Information for each company. The WUCS/EUC shall post the EURP in an area readily accessible to the Department and project personnel. Also, WUCS shall distribute the copies of EURP by e-mail and hard copy to GA DOT Area Engineer, GA DOT Construction Project Engineer, Contractor's project manager, superintendent, and all approved sub-contractors whose work can be in conflict with utilities facilities, personnel of the each facility/owner/ operator who has facilities within the project limits and keep a copy in close proximity to active construction.

In the event of interruption to gas, water or other utility services as a result of accidental breakage or as a result of being exposed or unsupported, the WUCS/EUC shall promptly notify the appropriate emergency officials, the Georgia Utilities Protection Center and the appropriate utility facility company or operator, if known. Until such time as the damage has been repaired, no person shall engage in excavating or blasting activities that may cause further damage to the utility facility.

In order to keep up with the latest / most updated EURP contact information (name and phone numbers); WUCS shall include an item in the agenda of Utility Coordination meeting about the updates / changes in the EURP plan.

The Emergency Utility Response Plan and Emergency Utility Response Information template can be found at the State of Georgia, Office of Utilities Webpage.

F. Submission

Provisions for reporting all utility coordination meetings, the progress of utility relocation and adjustment work milestones and ticket status information will be reported on a form developed by the WUCS and will be distributed by the WUCS to all of the utility companies as milestones are met and shall be included as part of the project records. These reports shall be delivered to the Engineer for review, on a monthly basis. The WUCS shall immediately report to the Engineer any delay between the utility relocation and adjustment work, the existing Utility Adjustment Schedule, or the proposed Utility Adjustment Schedule so that these differences can be reconciled.

G. Delays

Delays and interruptions to the controlling Item or Items of The Work caused by the adjustment or repair of water, gas, or other utility appurtenances and property may be considered for an extension of Contract Time as provided in Subsection 108.07.E unless such delays are due to the negligence of the Contractor.

H. Facilities Supported on Bridges

If the utility facilities are to be supported on bridges, the following provisions shall apply:

1. The Plans will show the location of the facility and the auxiliary items necessary to support the facility.
2. The Contractor constructing the bridge shall install anchor bolts, thimbles, inserts, or other auxiliary items attached to the bridge as a part of the support for the utility facility. The Utility Company shall furnish these auxiliary items, unless the Contract indicates these items are to be furnished by the Contractor as a part of the bridge construction.
3. The Utility or its subcontractor constructing the utility facility shall install hanger rods, pipe rollers, and other attachments necessary for the support of the utility facility as indicated on the Plans. The Utility Company shall furnish these attachments at no cost to the Department or the prime contractor unless otherwise specified. This work shall also include:
 - a. Caulking the openings around the utility where it passes through endwalls to prevent the passage of undesirable materials.
 - b. Painting the exposed portions of utility supports unless such supports are corrosion resistant. Painting shall be done in accordance with the applicable portions of Section 535, unless otherwise specified.
4. The sequence of bridge construction work may be set forth in the Plans and/or the Special Provisions and will show at what stage of the Work a utility company will be allowed to make the utility installation. Further, all or any portion of The Work under Subsection 107.21.H.3 may be included in the bridge Contract by the Plans and/or the Special Provisions.
5. Any damage to the bridge structure caused by the utility installation shall be repaired to the satisfaction of the Engineer at the expense of the Utility or its subcontractor installing the utility facility.

I. Clearances

The Plans provide for at least minimum clearance of utilities as required by the National Electrical Safety Code, U.S. Department of Commerce, and National Bureau of Standards. Any additional clearance the Contractor may desire or require in performing The Work shall be arranged by the Contractor with the utility company. The Department will pay no extra compensation for such additional clearances.

J. Utility Relocation Progress Schedule

The purpose of the Utility Adjustment Schedule is to provide the Contractor with the pertinent information, including any utility staging required, dependent activities, or joint-use coordination that is required for the creation of a feasible progress schedule. A suitable Utility Adjustment Schedule form is available from the Department for the WUCS to circulate to utility companies for any proposed project construction staging or should a utility company not duly file a Utility Adjustment Schedule to the Department during the preconstruction phase of the project. The WUCS shall submit a Utility Relocation Progress Schedule showing together the Progress Schedule Chart referenced in Section 108.03 and the proposed Utility Adjustment Schedules from all utility companies to the Engineer for review and approval. Copies of existing Utility Adjustment Schedules with utility companies having facilities on this project will be made available at the Georgia Department of Transportation, Office of Construction Bidding Administration, located at One Georgia Center, 600 West Peachtree Street, NW, Atlanta, GA 30308, for examination by the Contractor. The Utility Adjustment Schedules are available on-line at: www.dot.ga.gov/partner_smart/contractors/bidding_letting/bidx/default.aspx

K. Compensation

There will be no separate measurement or payment for this Work. The cost associated with this Work shall be included in the overall Bid submitted.

107.22 Hazardous and/or Toxic Waste

When the Contractor's operations encounter or expose any abnormal condition which may indicate the presence of a hazardous and/or toxic waste, such operations shall be discontinued in the vicinity of the abnormal condition and the Engineer shall be notified immediately. The presence of barrels, discolored earth, metal, wood, or visible fumes, abnormal odors, excessively hot earth, smoke, or anything else which appears abnormal may be indicators of hazardous and/or toxic wastes and shall be treated with extraordinary caution as they are evidence of abnormal conditions.

The Contractor's operations shall not resume until so directed by the Engineer.

Disposition of the hazardous and/or toxic waste will be made in accordance with the requirements and regulations of the Department of Human Resources and the Department of Natural Resources. Where the Contractor performs work necessary to dispose of hazardous and/or toxic waste, payment will be made at the unit prices for pay items included in the contract which are applicable to such work or, where the contract does not include such pay items, payment will be as provided in Subsection 109.05, "Extra Work."

107.23 Environmental Considerations

A. Construction

Erosion control measures shall be installed, to the greatest practical extent, prior to clearing and grubbing. Particular care shall be exercised along stream buffers, wetlands, open waters and other sensitive areas to ensure that these areas are not adversely affected.

Construction equipment shall not cross streams, rivers, or other waterways except at temporary stream crossing structures shown on the plans or as allowed by permit.

Construction activities within wetland areas are prohibited except for those within the construction limits as shown on the Plans and as specified in Subsection 107.23.E.

All sediment control devices (except sediment basins) installed on a project shall, as a minimum, be cleaned of sediment when one half the capacity, by height, depth or volume, has been reached. Sediment basins shall be cleaned of sediment when one-third the capacity by volume has been reached.

B. Bridge Construction Over Waterways

Construction waste or debris, from bridge construction or demolition, shall be prevented from being allowed to fall or be placed into wetlands, streams, rivers or lakes.

Excavation, dewatering, and cleaning of cofferdams shall be performed in such a manner as to prevent siltation. Pumping from cofferdams to a settling basin or a containment unit will be required if deemed necessary by the Engineer.

Operations required within rivers or streams, i.e. jetting or spudding, shall be performed within silt containment areas, cofferdams, silt fence, sediment barriers or other devices to minimize migration of silt off the project.

C. Environmental Clearance of Local Material or Disposal Sites

Specific written environmental approval from the Engineer will be required for any local material or disposal sites not included in the Plans. No work shall be started at any potential local material or waste site not shown on the plans prior to receiving said environmental approval from the Engineer. Local material sites are defined as borrow pits, common borrow, base, embankment, sand clay base, topsoil base, soil cement base, granular embankment, asphalt sand, maintenance pits, or stockpiled borrow sources. Disposal sites, as defined in Standard Specification 201.3.05.E.3, may be defined as excess material, common fill, or inert waste.

The Contractor may obtain environmental approval on a site with one of two methods: 1) GDOT provided environmental surveys or 2) environmental surveys obtained by the Contractor at no cost to the Department. The Contractor must choose one method for review and approvals, which will apply to all sites required for a given project, and submit an Environmental Review Notification indicating their chosen method.

1. If the Contractor chooses to obtain their own environmental surveys, they shall be conducted by a consultant(s) prequalified to work with the Department in the following area classes: 1.06(b) – History; 1.06(e) – Ecology; and 1.06(f) – Archaeology. Background research and field methods shall be conducted in accordance with the Office of Environmental Services Environmental Procedures Manual, with documentation in an Environmental Survey Results Memorandum (template available from the Office of Environmental Services).
2. If the Contractor requests that GDOT conduct required environmental surveys, an Environmental Survey Request shall be submitted for each site (template available from the Office of Environmental Services).

Upon receipt of an Environmental Survey Request, the Office of Environmental Services shall provide environmental approval or denial within thirty (30) business days. Upon receipt of an Environmental Survey Results Memorandum, the Office of Environmental Services shall provide environmental approval or denial within ten (10) business days. The Department will not accept requests for review of sites before a Notice to Proceed is issued. Incomplete Survey Requests, surveys that are not conducted by a GDOT prequalified consultant, or surveys that do not meet the required level of field effort or documentation, will be denied by GDOT OES and may require resubmittal.

The Engineer will inform the Contractor in writing as to the approval or denial of environmental clearance. Approvals may be provided upon condition that an Environmentally Sensitive Area (ESA) be designated within or adjacent to the site prior to use. All ESA stipulations shall be adhered to in accordance with Standard Specification 107.23.F. If a site is denied, the Contractor may, at no expense to the Department, seek to obtain permits or pursue other remedies that might otherwise render the site(s) acceptable, if available. Any and all changes to proposed sites or their associated haul roads that are not included within the original Environmental Survey Request or Environmental Survey Results Memorandum, including expansion, utilization for purposes other than those indicated in the original submittal, etc. must be submitted for further environmental review and approval prior to use.

Sites included in the Plans have environmental clearance and shall be used only for the purpose(s) specified in the Plans or other contract documents. Should the Contractor wish to expand or utilize said sites for any purpose other than that provided for in the Plans or other contract documents, specific written environmental clearance as noted above shall be obtained.

D. Control of Pollutants

Pollutants or potentially hazardous materials, such as fuels, lubricants, lead paint, chemicals or batteries, shall be transported, stored, and used in a manner to prevent leakage or spillage into the environment. The Contractor shall also be responsible for proper and legal disposal of all such materials.

Equipment, especially concrete or asphalt trucks, shall not be washed or cleaned-out on the Project except in areas where unused product contaminants can be prevented from entering waterways.

E. Temporary Work in Wetlands Outside of the Construction Limits within the Right-of-Way and Easement Areas

Temporary work in wetlands (that are not delineated with orange barrier fence) will be subject to the following requirements:

1. Temporary work in wetlands shall be accomplished by using temporary structures, timber, concrete, soil with geotextile fabric, or other suitable matting. The area shall not be grubbed.
2. Soil matting shall be protected from erosion in accordance with the Specifications.
3. Whenever temporary work is required in Saltwater Marsh Wetlands, all temporary structures and/or matting shall be removed in their entirety prior to Final Acceptance of the Project. Matted and compressed soils shall be backfilled to their original ground elevation with material meeting the requirements of Section 212 – Granular Embankment.
4. Whenever temporary work is required in Freshwater Wetlands, all temporary structures and/or matting (exclusive of soil matting to be retained in the final roadway section) shall be removed in their entirety prior to Final Acceptance of the Project.
Once the temporary materials have been removed, the area shall be covered by Excelsior or Straw blankets according to Section 713 of the Specifications. The grassing and ground preparation referenced in Subsection 713.3.03, “Preparation”, will not be applicable to this Work.
5. The Engineer shall be notified so that a field inspection may be conducted to certify that the temporary materials were properly removed and that the area was properly restored. The Contractor shall be responsible for any corrective action required to complete this Work.
6. There will be no separate measurement or payment for this Work. The cost associated with this work shall be included in the overall Bid submitted.

F. Environmentally Sensitive Areas

Some archaeological sites, historic sites, wetlands, streams, stream and pond buffers, open waters and protected animal and plant species habitat within the existing/required Right-of-Way and easement areas may be designated as ENVIRONMENTALLY SENSITIVE AREAS (ESAs). These areas are shown on the applicable Plan sheets and labeled “ESA” (e.g. ESA – Historical Boundary, ESA – Wetland Boundary). The Department may require that some ESAs or portions thereof be delineated with orange barrier fence. The Contractor shall install, maintain, and replace as necessary orange barrier fence at ESAs as delineated in the Plan sheets.

The Contractor shall not enter, disturb, or perform any construction related activities, other than those shown on the approved plan sheets within areas designated as ESAs including ESAs or portions thereof not delineated with orange barrier fence. This includes but is not limited to the following construction activities: clearing and grubbing; borrowing; wasting; grading; filling; staging/stockpiling; vehicular use and parking; sediment basin placement; trailer placement; and equipment cleaning and storage. Also, all archaeological sites, historic sites, wetlands, streams, stream and pond buffers, open waters, and protected animal and plant species habitat that extend beyond the limits of existing/required Right-of- Way and easement areas shall be considered ESAs and the Contractor shall not perform any construction related activities (such as those listed above) within these areas or make agreements with property owners to occupy these areas for construction related activities (such as those listed above). The Contractor shall make all construction employees aware of the location(s) of each ESA and the requirement to not enter or otherwise disturb these areas.

If the Contractor is found to have entered an ESA, either within or outside the project area, for any purpose not specifically shown on the approved plan sheets, the Department may, at its discretion, issue a stop work order for all activities on the project except erosion control and traffic control until such time as all equipment and other items are removed and the ESA is restored to its original condition.

However, should damage to an ESA occur as a result of the Contractor's action in violation of this section, and notwithstanding any subsequent correction by the Contractor, the Contractor shall be liable for any cost arising from such action, including but not limited to, the cost of repair, remediation of any fines, or mitigation fees assessed against the Department by another government entity.

G. Protection of Migratory Birds and Bats

The following conditions are intended as a minimum to protect migratory birds and bats during construction activities.

1. Project personnel shall be advised about the potential presence and appearance of federally protected migratory birds, including the barn swallow (*Hirundo rustica*), cliff swallow (*Petrochelidon pyrrhonota*), and eastern phoebe (*Sayornis phoebe*), and that there are civil and criminal penalties for harassing, harming, pursuing, hunting, shooting, wounding, killing, capturing, or collecting these species in violation of the Migratory Bird Treaty Act of 1918. The law protects adults, fledglings, nestlings, eggs, and active nests. All bats are protected under Georgia state law (Official Code of Georgia § 27-1-28), with some species protected under the federal Endangered Species Act of 1973. Pictures and habitat information shall be posted in a conspicuous location in the Project field office until such time that construction has been completed and time charges have stopped.
2. The demolition of existing bridge and culvert, the extension of existing culvert, and bridge maintenance activities on the underside of the bridge deck shall take place outside of the breeding and nesting season of phoebes, swallows and other migratory birds, which begins April 1 and extends through August 31, unless exclusionary barriers are put in place to prevent birds from nesting. For bridges, exclusionary barriers may be made of plastic, canvas or other materials proposed by the Contractor and approved by the State Environmental Administrator prior to installation. For box culverts, exclusionary barriers may be overlapping strips of flexible plastic (also called "PVC Strip Doors" or "Strip Curtains") or an alternate material proposed by the Contractor and approved by the State Environmental Administrator prior to installation. Exclusionary barriers must be installed on the bridge(s) and/or box culvert(s) prior to March 1 or after August 31, but in no time in between this period. Exclusionary barriers are not a guaranteed method of preventing migratory birds from nesting beneath bridges and work schedules shall take into account the possibility that barriers will not be successful. If exclusionary barriers are to be used, these steps shall be followed:
 - a. The Project ecologist shall be notified by phone (404) 631-1100 of the decision to install exclusionary barriers and the date of the proposed installation prior to the installation of any exclusionary devices.
 - b. The structure(s) shall be checked for nests prior to the placement of exclusionary barriers. If nests are present, they shall be inspected to ensure that eggs or birds are not present. If the nests are found to be occupied, construction activities associated with the bridge shall be postponed until after August 31 when the breeding season is complete.
 - c. For any box culvert(s) being replaced, exclusionary barriers shall be installed on both the inlet and outlet openings. For any box culvert(s) being extended, exclusionary barriers shall be placed on the opening(s) (inlet and/or outlet) where work is taking place. For bridge(s) being removed, barriers shall be installed along the full length of the bridge(s). In all cases, barriers shall be installed prior to March 1 and left in place until August 31 or until the culvert removal, culvert extension, or bridge demolition is complete. If the exclusionary barriers fail to prevent nesting (i.e., birds are able to bypass barriers and build nests), construction activities associated with the bridge shall be postponed until after August 31.

- d. During construction activities, exclusionary barriers shall be inspected daily for holes or other defects that impair its ability to exclude migratory birds from nesting beneath the bridge. Any holes or defects shall be repaired immediately.
 - e. Entanglement and/or entrapment of barn swallows, cliff swallows, and eastern phoebes in exclusionary netting constitutes harm to migratory birds. Any entanglement and/or entrapment of migratory birds shall be reported immediately to the Project Engineer, who in turn will notify the State Environmental Administrator, Georgia Department of Transportation, Office of Environmental Services at (404) 631-1101.
3. Migratory birds may nest in other structures or natural features that will be impacted by construction activities. If active nests containing eggs are encountered within the footprint of construction activities, the finding shall be reported immediately to the Project Engineer, who in turn shall notify the State Environmental Administrator, Georgia Department of Transportation, Office of Environmental Services at (404) 631-1101. All activity within 50 feet of active nests shall cease pending consultation by the Department with the U. S. Fish and Wildlife Service and the lead Federal Agency.
 4. When working on bridges and culverts, sightings of bat species shall be reported immediately to the Project Engineer who in turn will notify the State Environmental Administrator, Georgia Department of Transportation, Office of Environmental Services at (404) 631-1101. All construction activity on the structure shall cease pending consultation by the Department with the U. S. Fish and Wildlife Service and/or the Georgia Department of Natural Resources and/or the lead Federal Agency. The Department will inform the Contractor of any changes to the project.
 5. In the event any incident occurs that causes harm or injury to migratory birds during construction activities, the incident shall be reported immediately to the Project Engineer who in turn shall notify the State Environmental Administrator, Georgia Department of Transportation, Office of Environmental Services at (404) 631-1101. All activity shall cease pending consultation by the Department with the U. S. Fish and Wildlife Service and the lead Federal Agency.
 6. Within 30 days of the completion of construction and the stopping of time charges, a report shall be provided to the State Environmental Administrator, Georgia Department of Transportation, Office of Environmental Services, 600 West Peachtree Street NW, Atlanta, Georgia 30308. GDOT in turn will provide copies of the report to the U.S. Fish and Wildlife Service, the Georgia Department of Natural Resources Wildlife Resources Division, and the lead Federal Agency. The following information will be included in the report:
 - a. Contractor name and address.
 - b. Name and title of report preparer.
 - c. GDOT Project Identification (PI) number.
 - d. County(s) in which project is located.
 - e. Project description.
 - f. Construction start and end dates.
 - g. Date GDOT was notified of intent to install barrier(s) per # 107.23G.2.a.
 - h. Number and type(s) of structures on which exclusion barriers were installed.
 - i. Type(s) of exclusion material used on each structure.

- j. Start and end date(s) of installation of exclusionary barrier on each structure.
 - k. Start and end date(s) of removal of exclusionary barrier from each structure.
 - l. Photographs of each structure before and after exclusionary barrier installation.
 - m. Statement regarding whether the exclusionary barrier was effective in deterring bird use of the structure during construction.
 - n. Description of any incidents causing harm or injury to migratory birds during construction. This should include incidents that were reported as required under 107.23G.5.
 - o. Description of any sightings of bat species when working on bridges and culverts. This should include incidents that were reported as required under 107.23G.4.
7. All costs pertaining to any requirement contained herein shall be included in the overall bid submitted unless such requirement is designated as a separate Pay Item in the Proposal.

107.24 Closing of Roadways without On-Site Detours

When existing roadways are to be closed to through traffic and on-site detours are not provided, the Contractor shall submit a written notice to the Engineer for approval 14 days prior to the closure of the existing roadways.

After receiving approval from the Engineer for the closure, the Contractor shall install signs at each closure site, in accordance with the MUTCD, to inform the traveling public of the proposed closure, including the date of closure. The sign shall be placed 5 days prior to the closure, at the direction of the Engineer.

Prior to the closure, the Area Engineer will inform local government officials and agencies, local news media, and the DOT Public Information Office of the proposed closure of the roadways.

107.25 Disruption to Residential and Commercial Property

The Contractor shall plan, coordinate, and prosecute the work such that disruption to personal property and business is held to a practical minimum.

All construction areas abutting lawns and yards of residential or commercial property shall be restored promptly. Backfilling of each drainage structure or section of curb and gutter, sidewalk, or driveway shall be accomplished as soon as adequate strength is obtained. Finishing, dressing and grassing shall be accomplished immediately thereafter as a continuous operation within each area being constructed with emphasis placed on completing each individual yard or business frontage. Care shall be taken to provide positive drainage to avoid ponding or concentration of runoff.

Handwork, including raking and smoothing, shall be required to ensure that roots, sticks, rocks, and other debris is removed in order to provide a neat and pleasing appearance. Grassing, when in season, shall immediately follow in order to establish permanent cover at the earliest date. If grassing is not in season, proper erosion control shall be installed and maintained.

The work described herein shall be in addition to that required by Subsection 104.07 "Final Cleaning Up" and Subsection 105.16 "Final Inspection and Acceptance."

Section 109—Measurement and Payment

Delete Subsection 109 and Substitute the following:

109.01 Measurement and Quantities

The method of measurement and computations to be used in determination of quantities of material furnished and of work performed under the Contract will be those methods generally recognized as conforming to good engineering practice.

Unless otherwise specified, longitudinal measurements for area computations will be made along the surface, and no deductions will be made for individual fixtures having an area of 9 ft² (1 m²) or less. Unless otherwise specified, transverse measurements for area computations will be the neat dimensions shown on the Plans or ordered in writing by the Engineer.

Where payment is to be made by the square yard (square meter) for a specified thickness, the length will be measured on the surface along the centerline and the pay width shall be that width specified on the plans for the Final surface of the completed section. Intermediate courses shall be placed at a width sufficient to support successive courses with no detriment to the stability of the successive courses. The width of material required beyond the pay width will not be eligible for payment and shall be considered incidental to the work.

Structures will be measured according to neat lines shown on the Plans or as altered to fit field conditions.

All items which are measured by the linear foot (linear meter), such as pipe culverts, guard rail, underdrains, etc., will be measured parallel to the base or foundation upon which such structures are placed, unless otherwise shown on the Plans.

In computing volumes of excavation, the average end area method or other acceptable methods will be used.

The term “gage,” when used in connection with the measurement of steel plates, will mean the U.S. Standard Gage.

When the term “gage” refers to the measurement of electrical wire it will mean the wire gage specified in the National Electrical Code.

The term “ton” will mean the short ton consisting of 2,000 pounds avoirdupois. The term “megagram” will mean one metric ton, equivalent to 1,000 kg. Any commodity paid for by weight shall be weighed on scales that have been approved as specified below and which are furnished at the expense of the Contractor or Supplier. Weighing and measuring systems including remote controls shall be subject to type-approval by the Department of Transportation. The manufacture, installation, performance, and operation of such devices located in Georgia shall conform to, and be governed by, the Official Code of Georgia, Annotated, Section 10-2-5 of the Georgia Weights and Measures Act, the Georgia Weights and Measures Regulations, as amended and adopted, the current edition of the National Bureau of Standards Handbook 44, and these Specifications. Weighing and measuring systems located outside Georgia which are utilized for weighing materials to be used in Department work shall be manufactured, installed, approved, and operated in accordance with applicable laws and regulations for the state in which the scales are located.

All weighing, measuring, and metering devices used to measure quantities for payment shall be suitable for the purpose intended and will be considered to be “commercial devices.” Commodity scales located in Georgia shall be certified before use for accuracy, condition, etc., by the Weights and Measures Division of the Georgia Department of Agriculture, or its authorized representative. Scales located outside Georgia shall be certified in accordance with applicable laws and regulations for the state in which the scales are located. This certification shall have been made within a period of not more than one year prior to date of use for weighing commodity.

All equipment and all mechanisms and devices attached thereto or used in connection therewith shall be constructed, assembled, and installed for use so that they do not facilitate the perpetration of fraud. Any scale component or mechanism, which if manipulated would alter true scale values (including manual zero setting mechanisms) shall not be accessible to the scale operator. Such components and mechanisms that would otherwise be accessible to the scale operator shall be enclosed. Provisions shall be made for security seals where appropriate on equipment and accessories. A security seal shall be affixed to any adjustment mechanism designed to be sealed. Scale or accessory devices shall not be used if security seals have been broken or removed.

Any certified scale or scale component which has been repaired, dismantled, or moved to another location shall again be tested and certified before it is eligible for weighing.

Whenever materials that are paid for based on weight are from a source within the State, the scales shall be operated by and the weights attested to by signature and seal of a duly authorized Certified Public Weigher in accordance with Standard Operating Procedure 15 and the Official Code of Georgia, Annotated, Section 10-2-5 of the Georgia Weights and Measures Act as amended and adopted. When such materials originate from another state that has a certified or licensed weigher program, the scales shall be operated by a weigher who is certified by that state in accordance with applicable laws, and weight ticket recordation shall be in accordance with Standard Operating Procedure 15.

When materials are paid for based on weight and originate from another state which has no program for certifying or licensing weighers, the materials shall be weighed on scales located in the State of Georgia by a Certified Public Weigher in accordance with Standard Operating Procedure 15 and the Official Code of Georgia, Annotated, Section 10-2-5 of the Georgia Weights and Measures Act as amended and adopted.

No scale shall be used to measure weights greater than the scale manufacturer's rated capacity. A digital recorder shall be installed as part of any commodity scale. The recorder shall produce a printed digital record on a ticket with the gross, tare, and net weights of the delivery trucks, along with the date and time printed for each ticket. Provisions shall be made so that the scales or recorders may not be manually manipulated during the printing process. The system shall be so interlocked as to allow printing only when the scale has come to rest. Either the gross or net weight shall be a direct scale reading. Printing and recording systems that are capable of accepting keyboard entries shall clearly and automatically differentiate a direct scale weight value from any other weight values printed on the load ticket.

All scales used to determine pay quantities shall be provided to attain a zero balance indication with no load on the load receiving element by the use of semi-automatic zero (push-button zero) or automatic zero maintenance.

Vehicle scales shall have a platform of sufficient size to accommodate the entire length of any vehicle weighed and shall have sufficient capacity to weigh the largest load. Adequate drainage shall be provided to prevent saturation of the ground under the scale foundation.

The Engineer, at his discretion, may require the platform scales to be checked for accuracy. For this purpose the Contractor shall load a truck with material of his choosing, weigh the loaded truck on his scales, and then weigh it on another set of certified vehicle scales. When the difference exceeds 0.4 percent of load, the scales shall be corrected and certified by a registered scale serviceman registered in the appropriate class as outlined in the Georgia Weights and Measures Regulations or in accordance with applicable requirements of the state in which the scales are located. A test report shall be submitted to the appropriate representative of the Department of Agriculture.

Materials to be measured by volume in the hauling vehicle shall be hauled in approved vehicles and measured therein at the point of delivery. Vehicles for this purpose may be of any size or type acceptable to the Engineer, provided that the body is of such shape that the actual contents may be readily and accurately determined. All vehicles shall be loaded to their water level capacity as determined by the Engineer, provided that the body is of such shape that the actual contents may be readily and accurately determined.

Cement and lime will be measured by the ton (megagram). Whenever cement or lime is delivered to the Project in tank trucks, a certified weight shall be made at the shipping point by an authorized Certified Public Weigher who is not an employee of the Department. Whenever cement and lime are from a source within the State, the scales shall be operated by the weights attested to by signature and seal of a duly authorized Certified Public Weigher in accordance with Standard Operating Procedure 15 and the Official Code of Georgia, Annotated, Section 10-2-5 of the Georgia Weights and Measures Act as amended and adopted. When such materials originate from another state that has a certified or licensed weigher program, the scales shall be operated by a weigher who is certified by that state in accordance with applicable laws, and the weight ticket recordation shall be in accordance with Standard Operating Procedure 15. When cement and lime originate from another state that has no program for certifying or licensing weighers, the materials shall be weighed on scales located in the State of Georgia by a Certified Public Weigher in accordance with Standard Operating Procedure 15 and the Official Code of Georgia, Annotated, Section 10-2-5 of the Georgia Weights and Measures Act as amended and adopted.

The shipping invoice shall contain the certified weights and the signature and seal of the Certified Public Weigher. A security seal shall also be affixed to the discharge pipe cap on the tank truck before leaving the shipping point. The number on the security seal shall also be recorded on the shipping invoice. The shipping invoice for quicklime shall also contain a certified lime purity percentage. Unsealed tank trucks will require reweighing by a Certified Public Weigher.

Timber will be measured by the thousand feet board measure (MFBM) (cubic meter) actually incorporated in the structure. Measurements will be based on nominal widths and thickness and the actual length in place. No additional measurement will be made for splices except as noted for overlaps as shown on the Plans.

The term "Lump Sum" when used as an item of payment will mean complete payment for The Work described in the Contract.

When a complete structure or structural unit (in effect, "Lump Sum" work) is specified as the unit of the measurement, the unit will be construed to include all necessary fittings and accessories.

Rental of equipment will be measured as defined in Subsection 109.05.B.4.

When standard manufactured items are specified as fence, wire, plates, rolled shapes, pipe conduits, etc., and these items are identified by gage, unit weight, section dimensions, etc., such identification will be considered to be nominal weights or dimensions. Unless more stringently controlled by tolerance in cited Specifications, manufacturing tolerances established by the industries involved will be accepted.

109.02 Measurement of Bituminous Materials

A. By Weighing the Material

The Department prefers this method whenever it is practicable. This method will be considered acceptable under the following conditions:

1. **Weighed On Project:** If the weights of the bituminous materials delivered by tank trucks are to be determined on the Project, weights shall be determined on scales that have been previously checked by the Department with standard weights for accuracy. The scale platform shall be large enough to accommodate the entire vehicle at one time. Under no conditions will truck scales be used to measure weights greater than their rated capacity. All weights not determined in the presence of an authorized representative of the Department shall be made by a Certified Public Weigher who is not an employee of the Department of Transportation and who is in good standing with the Georgia Department of Agriculture. The weight tickets shall carry both the signature and seal of the Certified Public Weigher.
2. **Weighed At Shipping Point:** A certified weight made at the shipping point by an authorized Certified Public Weigher who is not an employee of the Department of Transportation and who is registered with the Georgia Department of Agriculture, will be acceptable provided all openings in the tank have been sealed by the producer and when, upon inspection on the Project, there is no evidence of any leakage. The shipping ticket in this case must carry the signature and seal of the Certified Public Weigher. If the tank is not completely emptied the amount of material remaining in the tank truck will be measured by either weight or volume and the amount so determined, as verified by the Engineer, will be deducted from the certified weight.
3. **By Extraction Analysis:** The weight of bituminous material used will be determined by extraction tests made by the field laboratory. The average asphalt content for each Lot will be used to compute the weight of the Asphalt Cement to be paid for in accordance with the following formula:

English:

$$P = \% AC \times T$$

Where:

P = Pay Tons of Asphalt Cement

% AC = Lot average of % Asphalt Cement by weight of total mix as determined by extraction

T = Actual accepted tons of mixture as weighed

Metric:

$$P = \% AC \times T$$

Where:

P = Pay megagrams of Asphalt Cement

% AC = Lot average of % Asphalt Cement by weight of total mix as determined by extraction

T = Actual accepted megagrams of mixture as weighed

4. **By Digital Recording Device:** The amount of bituminous material as shown on the printed tickets will be the Pay Quantity.

B. By Volume

The volume will be measured and corrected for the difference between actual temperature and 60 °F (15 °C). Containers shall be level when measured, and one of the following methods shall be used, whichever is best suited to the circumstances:

1. **Tank Car Measurement:** If the material is shipped to the Project in railroad tank cars, the Contractor shall furnish the Engineer a certified chart showing the dimensions and volume for each inch (25 mm) of depth for each tank. The Engineer will make outage and temperature measurements before unloading is begun and after it is finished. The measurements will be taken when the bituminous material is at a uniform temperature and free from air bubbles. The

Contractor shall not remove any bituminous material from any tank until necessary measurements have been made nor shall he release the car until final outage has been measured. The total number of gallons (liters) allowed for any tank car shall not be more than the U.S. Interstate Commerce Commission rating for that car, converted to gallons at 60 °F (15 °C).

2. **Truck Measurement:** If bituminous materials are delivered to the Project in tank trucks, distributor tanks, or drums, the Contractor shall not remove any bituminous material from the transporting vehicle or container until necessary measurements have been made, nor shall the transporting vehicle or container be released until final outage has been measured. If weighing is not convenient, the Contractor shall furnish the Engineer with a certified chart showing the dimensions and volume of each container together with a gauge or calibrated measuring rod which will permit the volume of the material to be determined by vertical measurement.
3. **Metering:** The volume may be determined by metering, in which case the metering device used and the method of using it shall be subject to the approval of the Engineer.
4. **Time of Deliveries:** The arrival and departure of vehicles delivering bituminous materials to the Project site shall be so scheduled that the Engineer is afforded proper time for the measurements of delivered volume and final outage. The Engineer will make the necessary measurements only during the Contractor's normal daily working hours.

C. Production for Multiple Projects

When a Contractor is producing Asphaltic Concrete from one plant, which is being placed on two or more jobs, public or private, the amount of bituminous material used may be determined by extraction tests in accordance with Subsection 109.02.A.3 or digital recording device in accordance with Subsection 109.02.A.4.

D. Tack Coat

When the same storage facility is utilized for Bituminous Materials to be used in Hot Mix Asphaltic Concrete, Bituminous Tack Coat, and/or Surface Treatment, the quantity used for Tack Coat shall be converted to tons (megagrams) and deducted from the quantities for the Bituminous Material used in the Hot Mix Asphaltic Concrete and Surface Treatment.

E. Corrections

When the volume and temperature have been determined as defined above, the volume will be corrected by the use of the following formula:

$$V_{\text{English}} = \frac{V1}{K(t-60) + 1} \qquad V_{\text{metric}} = \frac{V1}{K(t-15) + 1}$$

Where:

V = Volume of bituminous material at 60 °F (15 °C)

V1= Volume of hot bituminous material

t = Temperature of hot bituminous material in degrees Fahrenheit (Celsius)

K= Coefficient of Expansion of bituminous material (correction factor)

The correction factors K for various materials are given below:

- 0.00035 (0.00063) per °F (°C) for petroleum oils having a specific gravity of 60 °F/60 °F (15 °C/15 °C) above 0.966
- 0.00040 (0.00072) per °F (°C) for petroleum oils having a specific gravity of 60 °F/60 °F (15 °C/15 °C) between 0.850-0.966
- 0.00030 (0.00054) per °F (°C) for Tar
- 0.00025 (0.00045) per °F (°C) for Emulsified Asphalt
- 0.00040 (0.00072) per °F (°C) for Creosote Oil

109.03 Scope of Payment

The Contractor shall receive and accept the compensation provided for in the Contract as full payment for furnishing all materials, labor, tools, equipment, superintendence and incidentals, and for performing all work contemplated and embraced under the Contract in a complete and acceptable manner, for any infringement of patent, trademark or copyright, for all loss or damage arising from the nature of The Work, or from the action of the elements, for all expenses incurred by or in consequence of the suspension or discontinuance of The Work, or from any unforeseen difficulties which may be encountered during the prosecution of The Work and for all risks of every description connected with the prosecution of The Work until its Final Acceptance by the Engineer, except as provided in Subsection 107.16.

The payment of any partial estimate prior to Final Acceptance of the Project as provided in Subsection 105.16 shall in no way affect the obligation of the Contractor to repair or renew any defective parts of the construction or to be responsible for all damages due to such defects.

109.04 Payment and Compensation for Altered Quantities

When alteration in Plans or quantities of work not requiring Supplemental Agreements as herein before provided for are ordered and performed, the Contractor shall accept payment in full at the Contract Unit Bid Prices for the actual quantities of work done, and no allowance will be made for increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor, resulting either directly from such alterations, or indirectly from unbalanced allocation among the Contract Items of overhead expense on the part of the Bidder and subsequent loss of expected reimbursement therefore, or from any other cause.

Compensation for alterations in Plans or quantities of work requiring Supplemental Agreements shall be as stipulated in such agreement, except that when the Contractor proceeds with The Work without change of price being agreed upon, he shall be paid for such increased or decreased quantities at the Contract Unit Prices Bid in the Proposal for the Items of The Work.

109.05 Extra Work

Extra work, as defined in Subsection 101.27, when ordered in accordance with Subsection 104.04, will be authorized in writing by the Engineer. The authorization will be in the form of a Supplemental Agreement or a Force Account.

A. Supplemental Agreement

In the case of a Supplemental Agreement, the work to be done will be stipulated and agreed upon by both parties prior to any extra work being performed.

Payment based on Supplemental Agreements shall constitute full payment and settlement of all additional costs and expenses including delay and impact damages caused by, arising from or associated with The Work performed.

B. Force Account

When no agreement is reached for Extra Work to be done at Lump Sum or Unit Prices, such work may be authorized by the Department to be done on a Force Account basis. A Force Account estimate that identifies all anticipated costs shall be prepared by the Contractor on forms provided by the Engineer. Work shall not begin until the Force Account is approved. Payment for Force Account work will be in accordance with the following:

1. **Labor:** For all labor, equipment operators and supervisors, excluding superintendents, in direct charge of the specific operations, the Contractor shall receive the rate of wage agreed upon in writing before beginning work for each and every hour that said labor, equipment operators and supervisors are actually engaged in such work.
The Contractor shall receive the actual costs paid to, or in behalf of, workers by reason of subsistence and travel allowances, health and welfare benefits, pension fund benefits, or other benefits, when such amounts are required by collective bargaining agreement or other employment contract generally applicable to the classes of labor employed on The Work.
An amount equal to 15% of the sum of the above items will also be paid the Contractor.
2. **Bond, Insurance, and Tax:** For property damage, liability, and worker's compensation insurance premiums, unemployment insurance contributions, and Social Security taxes on the Force Account work, the Contractor shall receive the actual cost, to which cost no percentage will be added. The Contractor shall furnish satisfactory evidence of the rate or rates paid for such bond, insurance, and tax.
3. **Materials:** For materials accepted by the Engineer and used, the Contractor shall receive the actual cost of such material incorporated into The Work, including Contractor paid transportation charges (exclusive of machinery rentals as hereinafter set forth), to which cost 10% will be added.
4. **Equipment:** For any machinery or special equipment (other than small tools) including fuel and lubricant, plus transportation costs, the use of which has been authorized by the Engineer, the Contractor shall receive the rental rates indicated below for the actual time that such equipment is in operation on The Work or the time, as indicated below, the equipment is directed to stand by.

Equipment rates shall be based on the latest edition of the *Rental Rate Blue Book for Construction Equipment* or *Rental Rate Blue Book for Older Construction Equipment*, whichever applies, as published by EquipmentWatch using all instructions and adjustments contained therein and as modified below.

Allowable Equipment Rates shall be established as defined below:

- Allowable Hourly Equipment Rate = Monthly Rate/176 x Adjustment Factors.
- Allowable Hourly Operating Cost = Hourly Operating Cost.

- Allowable Rate Per Hour = Allowable Hourly Equipment Rate + Allowable Hourly Operating Cost.
- Standby Rate = Allowable Hourly Equipment Rate x 35%

NOTE: The monthly rate is the basic machine plus any attachments.

Standby rates shall apply when equipment is not in operation and is directed by the Engineer to standby for later use. In general, Standby rates shall apply when equipment is not in use, but will be needed again to complete The Work and the cost of moving the equipment will exceed the accumulated standby cost. Payment for standby time will not be made on any day the equipment operates for 8 or more hours. For equipment accumulating less than 8 hours operating time on any normal workday, standby payment will be limited to only that number of hours which, when added to the operating time for that day equals 8 hours. Standby payment will not be made on days that are not normally considered workdays.

The Department will not approve any rates in excess of the rates as outlined above unless such excess rates are supported by an acceptable breakdown of cost.

Payable time periods will not include:

- Time elapsed while equipment is broken down
- Time spent in repairing equipment, or
- Time elapsed after the Engineer has advised the Contractor the equipment is no longer needed

If a piece of equipment is needed which is not included in the above *Blue Book* rental rates, reasonable rates shall be agreed upon in writing before the equipment is used. All equipment charges by persons or firms other than the Contractor shall be supported by invoices.

Transportation charges for each piece of equipment to and from the site of The Work will be paid provided:

- The equipment is obtained from the nearest approved source
- The return charges do not exceed the delivery charges
- Haul rates do not exceed the established rates of licensed haulers, and
- Such charges are restricted to those units of equipment not already available and not on or near the Project

No additional compensation will be made for equipment repair.

- Miscellaneous:** No additional allowance will be made for general superintendence, the use of small tools, or other costs for which no specific allowance is herein provided.
- Compensation:** The Contractor's representative and the Engineer shall compare records and agree on the cost of work done as ordered on a Force Account basis at the end of each day on forms provided by the Department.
- Subcontract Force Account Work:** For work performed by an approved Subcontractor or Second-tier Subcontractor, all provisions of this Section (109.05) that apply to the Prime Contractor in respect to labor, materials and equipment shall govern. The prime Contractor shall coordinate the work of his Subcontractor. The prime Contractor will be allowed an amount to cover administrative cost equal to 5% of the Subcontractor's amount earned but not to exceed \$5,000.00 per Subcontractor. Markup for Second-tier Subcontract work will not be allowed. Should it become necessary for the Contractor or Subcontractor to hire a firm to perform a specialized type of work or service which the prime Contractor or Subcontractor is not qualified to perform, payment will be made at reasonable invoice cost. To each invoice cost a markup to cover administrative cost equal to 5% of the total invoice but not to exceed \$5,000.00 will be allowed the Contractor or Subcontractor but not both.
- Statements:** No payment will be made for work performed on a Force Account basis until the Contractor has furnished the Engineer with duplicate itemized statements of the cost of such Force Account work detailed as follows:
 - Name, classification, date, daily hours, total hours, rate, and extension for each laborer, equipment operator, and supervisor, excluding superintendents.
 - Designation, dates, daily hours, total hours, rental rate, and extension for each unit of machinery and equipment.
 - Quantities of materials, prices, and extensions.
 - Transportation of materials.
 - Cost of property damage, liability, and worker's compensation insurance premiums, unemployment insurance contributions, and Social Security tax.

Statements shall be accompanied and supported by invoices for all materials used and transportation charges. However, if materials used on the Force Account work are not purchased specifically for such work but are taken from the Contractor's stock, then, in lieu of the invoices, the Contractor shall furnish an affidavit certifying that such

materials were taken from his stock, that the quantity claimed was actually used, and that the price and transportation claimed represent the actual cost to the Contractor.

Payment based on Force Account records shall constitute full payment and settlement of all additional costs and expenses including delay and impact damages caused by, arising from or associated with The Work performed.

109.06 Eliminated Items

Should any Items contained in the Proposal be found unnecessary for the proper completion of The Work, the Engineer may, upon written order to the Contractor, eliminate such Items from the Contract, and such action shall in no way invalidate the Contract. When a Contractor is notified of the elimination of Items, he will be reimbursed for actual work done and all costs incurred, including mobilization of materials prior to said notifications.

109.07 Partial Payments

A. General

At the end of each calendar month, the total value of Items complete in place will be estimated by the Engineer and certified for payment. Such estimate is approximate only and may not necessarily be based on detailed measurements. Value will be computed on the basis of Contract Item Unit Prices or on percentage of completion of Lump Sum Items.

When so requested by the Contractor and approved by the Engineer, Gross Earnings of \$500,000.00 or more for work completed within the first 15 days of any month will be certified for payment on a semi-monthly basis subject to the conditions and provisions of Subsection 109.07.A, Subsection 109.07.B.6, Subsection 109.07.C, Subsection 109.07.D, Subsection 109.07.E, and Subsection 109.07.F.

B. Materials Allowance

Payments will be made on delivered costs, or percentage of bid price if otherwise noted, with copies of paid invoices provided to the Department for the materials listed below which are to be incorporated into the Project provided the materials:

- Conform to all Specification requirements.
- Are stored on the Project Right-of-Way or, upon written request by the Contractor and written approval of the Engineer, they may be stored off the Right-of-Way, but local to the Project, provided such storage is necessary due to lack of storage area on the Right-of-Way, need for security, or need for protection from weather.

As a further exception to on-Project storage, upon written request by the Contractor, the Engineer may approve off-the-Project storage items uniquely fabricated or precast for a specific Project, such as structural steel and precast concrete, which will be properly marked with the Project number and stored at the fabrication or precast facility.

The Engineer may approve out-of-state storage for structural steel and prestressed concrete beams uniquely fabricated for a specific Project stored at the fabrication facility.

1. Paid invoices should accompany the materials allowance request, but in no case be submitted to the Project Engineer later than 30 calendar days following the date of the progress payment report on which the materials allowance was paid.

In case such paid invoices are not furnished within the established time, the materials allowance payment will be removed from the next progress statement and no further materials allowance will be made for that item on that Project.

2. Materials allowances will be paid for those items which are not readily available, and which can be easily identified and secured for a specific project and for which lengthy stockpiling periods would not be detrimental. Some exclusions are as follows:
 - a. No payments will be made on living or perishable plant materials until planted.
 - b. No payments will be made on Portland Cement, Liquid Asphalt, or Grassing Materials.
 - c. No payment will be made for aggregate stockpiled in a quarry. Payment for stockpiled aggregate will be made only if the aggregate is stockpiled on or in the immediate vicinity of the project and is held for the exclusive use on that project. The aggregate must be properly secured. If the aggregate stockpiled is to be paid for per-ton (megagram) it must be reweighed on approved scales at the time it is incorporated into the Project.
 - d. No payments will be made on minor material items, hardware, etc.
3. No materials allowance will be made for materials when it is anticipated that those materials will be incorporated into The Work within 30 calendar days.

4. No materials allowance will be made for a material when the requested allowance for such material is less than \$25,000.
5. Where a storage area is used for more than one project, material for each project shall be segregated from material for other projects, identified, and secured. Adequate access for auditing shall be provided. All units shall be stored in a manner so that they are clearly visible for counting and/or inspection of the individual units.
6. Materials allowance for prestressed concrete and structural steel bridge members may be processed for uncast or unfabricated members upon the Engineer's receipt of a true copy of the binding order for the members required by the plan. Such copy shall be sealed and notarized by both the contractor placing the order and the supplier therein identified to cast or fabricate said members. All orders shall demonstrate conformance to the approved plans and specifications regarding beam type, size, length, material quantities and shall not exceed the approved plan quantity. The materials allowance applied to uncast prestressed concrete members will be made in amount equal to 40% of the invoice for the respective member(s) to the contractor. The materials allowance applied to unfabricated structural steel bridge members will be made in amount equal to 55% of the invoice for the respective member(s) to the contractor. An additional material allowance may be requested separately upon completion of the casting or fabricating for a maximum 90% of the invoice for the member(s) provided there is adherence to all other provisions of this specification.
7. The Commissioner may, at his discretion, grant waiver to the requirements of this Section when, in his opinion, such waiver would be in the public interest.

Subsequently, in the event the material is not on-hand and in the quantities for which the materials allowance was granted, the materials allowance payment will be removed from the next progress statement and no further materials allowance will be made for those items on that Project. If sufficient earnings are not available on the next progress statement, the Contractor agrees to allow the Department to recover the monies from any other Contract he may have with the Department, or to otherwise reimburse the Department.

Excluding item 6 above, payments for materials on hand shall not exceed the invoice price or 75 percent of the bid prices for the pay items into which the materials are to be incorporated, whichever is less.

C. Minimum Payment

No partial payment will be made unless the amount of payment is at least \$1000.00.

D. Liquidated Damages

Accrued liquidated damages will be deducted in accordance with Subsection 108.08.

E. Other Deductions

In addition to the deductions provided for above, the Department has the right to withhold any payments due the Contractor for items unpaid by the Contractor for which the Department is directly responsible, including, but not limited to, royalties (see Section 106).

F. Amount of Payment

The balance remaining after all deductions provided for herein have been made will be paid to the Contractor. Partial estimates are approximate and are subject to correction on subsequent progress statements. If sufficient earnings are not available on the subsequent progress statement, the Contractor agrees to allow the Department to recover the monies from any other Contract he may have with the Department, or to otherwise reimburse the Department. The Engineer is responsible for computing the amounts of all deductions herein specified, for determining the progress of the Work and for the items and amounts due to the Contractor during the progress of the Work and for the final statement when all Work has been completed.

G. Interest

Under no circumstances will any interest accrue or be payable on any sums withheld or deducted by the Department as authorized by Subsection 109.07.A, Subsection 109.07.B.6, Subsection 9.07.C, Subsection 109.07.D, Subsection 109.07.E, and Subsection 109.07.F.

H. Insert the Following in Each Subcontract

The Contractor shall insert the following in each Subcontract entered into for work under this Contract:

“The Contractor shall not withhold any retainage on Subcontractors. The Contractor shall pay the Subcontractor 100% percent of the gross value of the Completed Work by the Subcontractor as indicated by the current estimate certified by the Engineer for payment.”

Neither the inclusion of this Specification in the Contract between the Department and the Prime Contractor nor the inclusion of the provisions of this Specification in any Contract between the Prime Contractor and any of his Subcontractors nor any other Specification or Provision in the Contract between the Department and the Prime Contractor shall create, or be deemed to create, any relationship, contractual or otherwise, between the Department and any Subcontractor.

109.08 Final Payment

When Final Inspection and Final Acceptance have been made by the Engineer as provided in Subsection 105.16, the Engineer will prepare the Final Statement of the quantities of the various classes of work performed. All prior partial estimates and payments shall be subject to correction in the Final Statement. The District Engineer will transmit a copy of the Statement to the Contractor by Registered or Certified Mail. The Contractor will be afforded 35 days in which to review the Final Statement in the District Office before it is certified for payment by the Engineer. Any adjustments will be resolved by the District Engineer or in case of a dispute referred to the Chief Engineer whose decision shall be final and conclusive. After approval of the Final Statement by the Contractor, or after the expiration of the 35 days, or after a final ruling on disputed items by the Chief Engineer, the Final Statement shall be certified to the Treasurer by the Chief Engineer stating the Project has been accepted and that the quantities and amounts of money shown thereon are correct, due and payable.

The Treasurer, upon receipt of the Engineer's certification, shall in turn furnish the Contractor with the Department's Standard Release Form to be executed in duplicate. The aforesaid Release Form, showing the total amount of money due the Contractor, shall be sent to the Contractor by Registered or Certified Mail, to be delivered to such Contractor upon the signing of a return receipt card, to be returned to the Department in accordance with the provision of Federal law in respect to such matters and such return receipt card shall be conclusive evidence of a tender of said sum of money to the Contractor. Upon receipt of the properly executed Standard Release Form, the Treasurer shall make final payment jointly to the Contractor and his Surety. The aforesaid certification, executed release form, and final payment shall be evidence that the Commissioner, the Engineer, and the Department have fulfilled the terms of the Contract, and that the Contractor has fulfilled the terms of the Contract except as set forth in his Contract Bond.

The Standard Release Form is to be executed by the Contractor within 45 days after delivery thereof, as evidenced by the Registered or Certified Mail Return Receipt. Should the Contractor fail to execute the Standard Release Form because he disputes the Final Payment as offered, or because he believes he has a claim for damages or additional compensation under the Contract, the Contractor shall, within 45 days after delivery to the Contractor of the Standard Release Form, as evidenced by the Registered or Certified Mail Return Receipt, enter suit in the proper court for adjudication of his claim. Should the Contractor fail to enter suit within the aforesaid 45 days, then by agreement hereby stipulated, he is forever barred and stopped from any recovery or claim whatsoever under the terms of this Contract.

Should the Contractor fail to execute the Standard Release Form or file suit within 45 days after delivery thereof, then the Surety on the Contractor's Bond is hereby constituted the attorney-in-fact of the Contractor for the purpose of executing such final releases as may be required by the Department, including but not limited to the Standard Release Form, and for the purpose of receiving the Final Payment under this Contract.

The Department reserves the right as defined in Subsection 107.20, should an error be discovered in any estimates, to claim and recover from the Contractor or his Surety, or both, such sums as may be sufficient to correct any error of overpayment. Such overpayment may be recovered from payments due on current active Projects or from any future State work done by the Contractor.

The foregoing provisions of this Section shall be applicable both to the Contractor and the Surety on his Bond; and, in this respect, the Surety shall be bound by the provisions of Subsection 108.09 of these Specifications in the same way and manner as the Contractor.

A. Interest

In the event the Contractor fails to execute the *Standard Release Form* as prepared by the Treasurer because he disputes the amount of the final payment as stated therein, the amount due the Contractor shall be deemed by the Contractor and the Department to be an unliquidated sum and no interest shall accrue or be payable on the sum finally determined to be due to the Contractor for any period prior to final determination of such sum, whether such determination be by agreement of the Contractor and the Department or by final judgement of the proper court in the event of litigation between the Department and the Contractor. The Contractor specifically waives and renounces any and all rights it may have under Section 13-6-13 of the Official Code of Georgia and agrees that in the event suit is brought by the Contractor against the Department for any sum claimed by the Contractor under the Contract, for delay damages resulting from a breach of contract, for any breach of contract or for any extra or additional work, no interest shall be awarded on any sum found to be due from the Department to the Contractor in the final judgement entered in such suit. All final

judgements shall draw interest at the legal rate, as specified by law. Also, the Contractor agrees that notwithstanding any provision or provisions of Chapter 11 of Title 13 of the Official Code of Georgia that the provisions of this contract control as to when and how the Contractor shall be paid for The Work. Further, the Contractor waives and renounces any and all rights it may have under Chapter 11 of Title 13 of the Official Code of Georgia.

B. Termination of Department's Liability

Final payment will be in the amount determined by the statement as due and unpaid. The acceptance of the final payment or execution of the Standard Release Form or failure of the Contractor to act within 120 days as provided herein after tender of payment, or final payment to the Contractor's Surety in accordance with the provisions stipulated herein, shall operate as and be a release to the Department, the Commissioner, and the Engineer from all claims of liability under this contract and for any act or neglect of the Department, the Commissioner, or the Engineer.

109.09 Termination Clause

A. General

The Department may, by written notice, terminate the Contract or a portion thereof for the Department's convenience when the Department determines that the termination is in the State's best interest, or when the Contractor is prevented from proceeding with the Contract as a direct result of one of the following conditions:

1. An Executive Order of the President of the United States with respect to the prosecution of war or in the interest of national defense.
2. The Engineer and Contractor each make a determination, that, due to a shortage of critical materials required to complete the Work which is caused by allocation of these materials to work of a higher priority by the Federal Government or any agency thereof, it will be impossible to obtain these materials within a practical time limit and that it would be in the public interest to discontinue construction.
3. An injunction is imposed by a court of competent jurisdiction which stops the Contractor from proceeding with the Work and causes a delay of such duration that it is in the public interest to terminate the Contract and the Contractor was not at fault in creating the condition which led to the court's injunction.

The decision of the Engineer as to what is in the public interest and as to the Contractor's fault, for the purpose of Termination, shall be final.

4. Orders from duly constituted authority relating to energy conservation.

B. Implementation

When, under any of the conditions set out in Subsection A of this Section, the Contract, or any portion thereof, is terminated before completion of all Items of Work in the Contract, the Contractor shall be eligible to receive some or all of the following items of payment:

1. For the actual number of units of Items of Work completed, payment will be made at the Contract Unit Price.
2. Reimbursement for organization of the Work and moving equipment to and from the job will be considered where the volume of work completed is too small to compensate the Contractor for these expenses under the Contract Unit Prices. However, the Engineer's decision as whether or not to reimburse for organization of the Work and moving equipment to and from the job, and in what amount, shall be final.
3. Acceptable materials, obtained by the Contractor for the Work, that have been inspected, tested, and accepted by the Engineer, and that are not incorporated in the Work will, at the request of the Contractor, be purchased from the Contractor at actual cost as shown by receipted bills and actual cost records at such points of delivery as may be designated by the Engineer. This will include any materials that have been delivered to the project site or that have been specifically fabricated for the project and are not readily usable on other projects. It will not include materials that may have been ordered, but not delivered to the project site and that are readily usable on other projects (e.g., guard rail, stone, lumber, etc.).
4. For Items of Work partially completed, payment adjustments including payments to afford the Contractor a reasonable profit on work performed, may be made as determined by the Engineer based upon a consideration of costs actually incurred by the Contractor in attempting to perform the Contract.
5. No payment will be made, and the Department will have no liability, for lost profits on Work not performed. In particular, the Department will not be liable to the Contractor for all profits the Contractor expected to realize had the Project been completed, nor for any loss of business opportunities, nor for any other consequential damages.
6. In order that the Department may make a determination of what sums are payable hereunder, the Contractor agrees that, upon termination of the Contract, it will make all of its books and records available for inspection and auditing by the Department.

To be eligible for payment, costs must have been actually incurred, and must have been recorded and accounted for according to generally accepted accounting principles, and must be items properly payable under Department policies. Where actual equipment costs cannot be established by the auditors, payment for unreimbursed equipment costs will be made in the same manner as is provided in Subsection 109.05 for Force Account Work. Idle time for equipment shall be reimbursed at standby rates. In no case will the Contractor be reimbursed for idle equipment after the Engineer has advised the Contractor the equipment is no longer needed on the job. Refusal of the Contractor to allow the Department to inspect and audit all of the Contractor's books and records shall conclusively establish that the Department has no liability to the Contractor for any payment under this provision, and shall constitute a waiver by the Contractor of any claim for damages allegedly caused by breach or termination of the Contract. The amount payable under this provision, if any, is to be determined by the Engineer, whose determination will be final and binding.

7. The sums payable under this Subsection shall be the Contractor's sole and exclusive remedy for termination of the Contract.

C. Termination of a Contract

Termination of a Contract or a portion thereof shall not relieve the Contractor of his responsibilities for any completed portion of the Work, nor shall it relieve his Surety of its obligation for and concerning any just claims arising out of the Work performed.

109.10 Interest

In the event any lawsuit is filed against the Department alleging the Contractor is due additional money because of claims or for any breach of contract, the Contractor hereby waives and renounces any right it may have under O.C.G.A. Section 13-6-13 to prejudgment interest. Also, the Contractor agrees that notwithstanding any provision or provisions of Chapter 11 of Title 13 of the Official Code of Georgia that the provisions of this contract control as to when and how the Contractor shall be paid for The Work. Further, the Contractor waives and renounces any and all rights it may have under Chapter 11 of Title 13 of the Official Code of Georgia.

Section 156—GPS Specifications for Conveyance Structures GIS Mapping

Delete Section 156 and substitute the following:

156.1 General Description

Perform the items of this work according to this Specification.

This work includes:

- Collecting sub-meter locations and attributes for specified stormwater/drainage-related assets within the project limits.
- Compiling, processing, and submitting the GIS data in accordance with the Department's policies and guidelines.
- Maintaining quality control and quality assurance while performing the work.

156.1.01 Definitions

General Provisions 101 through 150

156.1.02 Related References

A. Standard Specifications

General Provisions 101 through 150

B. Referenced Documents

General Provisions 101 through 150

GDOT Policy: 8075-1-Database Design and Modeling Standard

GDOT Policy: 8075-5-Metadata Registry

GDOT Policy: 8085-1- Geospatial Data Policy and Standards

GDOT Policy: 8085-2- GPS Data Collection Policy

156.1.03 Submittals

General Provisions 101 through 150

156.2 Materials

General Provisions 101 through 150

156.3 Construction Requirements

General Provisions 101 through 150

156.3.01 Personnel

Furnish qualified personnel capable of performing the work in accordance with the Department's above-stated policies and procedures detailed in GDOT Publications on the Department's website.

156.3.02 Accuracy

Ensure that data will be accurate within 1 yard horizontally for all assets. Collect and process data in accordance with the Department's Policies and Procedures detailed in GDOT Publications.

156.3.03 Coordinate System

Submit the data to the Department in accordance with the Department's policies and procedures defined in GDOT Publications. See GDOT Policy 8085-1- Geospatial Data Policy and Standards.

Horizontal coordinate system definition:

Coordinate system name:

*Projected coordinate system name:

NAD_1983_Georgia_Statewide_Lambert
*Geographic coordinate system name:
GCS_North_American_1983

Planar: Map projection: *Map projection name: Lambert Conformal Conic
Lambert conformal conic:
*Standard parallel: 31.416667
*Standard parallel: 34.283333
*Longitude of central meridian: -83.500000
*Latitude of projection origin: 0.000000
*False easting: 0.000000
*False northing: 0.000000

Planar coordinate information:
*Planar coordinate encoding method: coordinate pair Coordinate representation:
*Abscissa resolution: 0.004167 *
Ordinate resolution: 0.004167
*Planar distance units: U.S. survey feet

Geodetic model:
*Horizontal datum name: North American Datum of 1983
*Ellipsoid name: Geodetic Reference System 80
*Semi-major axis: 6378137.000000
*Denominator of flattening ratio: 298.257222

Vertical coordinate system definition:
Altitude system definition:
*Altitude resolution: 1.000000
*Altitude encoding method: Explicit elevation coordinate included with horizontal coordinates

156.3.04 Format

Provide data in ESRI ArcGIS 10.2 or newer file-based geodatabase format.

156.3.05 Schema and Metadata

Provide all the data in compliance with GDOT Policy 8075-1-Database Design and Modeling Standard and GDOT Policy 8075-5-Metadata Registry for download.

156.3.06 Data Submittal

The data shall be submitted to the Engineer no later than the final inspection. All electronic file deliverables shall include the PI number and “MS4” in the file name.

156.4 Measurement

This work will not be measured separately for payment.

156.5 Payment

This contract item completed and accepted will be paid at the Lump Sum Price bid, and the payment will be full compensation for all work completed as required by the Department. Any unnecessary work, overruns, costs, etc., resulting from inaccurate data submitted by the Contractor will be deducted from Contractor payments.

Payment will be made under:

Item No. 156	GPS Data Collection and Submittal	Per Lump Sum
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Section 162—Erosion Control Check Dams

Delete Section 162

Section 163—Miscellaneous Erosion Control Items

Delete Section 163 and substitute the following:

163.1 General Description

This work includes constructing and removing:

- Silt control gates
- Temporary erosion control slope drains shown on the Plans or as directed
- Temporary sediment basins
- Sediment barriers and check dams
- Rock filter dams
- Stone filter berms
- Stone filter rings
- Temporary sediment traps
- Other temporary erosion control structures shown on the Plans or directed by the Engineer

This work also includes applying mulch (e.g., straw, hay, erosion control compost), and temporary grass.

163.1.01 Related References

A. Standard Specifications

Section 109—Measurement and Payment

Section 161—Control of Soil Erosion and Sedimentation

Section 171—Temporary Silt Fence

Section 500—Concrete Structures

Section 603—Riprap

Section 700—Grassing

Section 711—Turf Reinforcement Matting

Section 716—Erosion Control Mats (Slopes)

Section 720 – Triangular Silt Barrier

Section 800—Coarse Aggregate

Section 801—Fine Aggregate

Section 822—Emulsified Asphalt

Section 860—Lumber and Timber

Section 863—Preservative Treatment of Timber Products

Section 881—Fabrics

Section 890—Seed and Sod

Section 893—Miscellaneous Planting Materials

B. Referenced Documents

AASHTO M252

AASHTO M294

163.1.02 Submittals

Provide written documentation to the Engineer as to the average weight of the bales of mulch.

163.2 Materials

Provide materials shown on the Plans, such as pipe, spillways, wood baffles, and other accessories including an anti-seep collar, when necessary. The materials shall remain the Contractor's property after removal, unless otherwise shown on the Plans.

Materials may be new or used; however, the Engineer shall approve previously used materials before use.

Materials shall meet the requirements of the following Specifications:

Material	Section
Mulch	893.2.02
Temporary Silt Fence	171
Concrete Aprons and Footings shall be Class A	500
Riprap	603
Temporary Grass	700
Triangular Silt Barrier	720
Lumber and Timber	860.2.01
Preservative Treatment of Timber Products	863.1
Corrugated Polyethylene Temporary Slope Drain Pipe	AASHTO M252 or M294

163.2.01 Delivery, Storage, and Handling

General Provisions 101 through 150.

163.3 Construction Requirements

163.3.01 Personnel

General Provisions 101 through 150.

163.3.02 Equipment

General Provisions 101 through 150.

163.3.03 Preparation

General Provisions 101 through 150.

163.3.04 Fabrication

General Provisions 101 through 150.

163.3.05 Construction

A. Silt Control Gates

If silt control gates are required or are directed by the Engineer, follow these guidelines to construct them:

1. Clear and grade only that portion of the roadway within the affected drainage area where the drainage structure will be constructed.
2. Construct or install the drainage structure and backfill as required for stability.
3. Install the silt control gate at the inlet of the structure. Use the type indicated on the Plans.
4. Vary the height of the gate as required or as shown on the Plans.
5. Finish grading the roadway in the affected drainage area. Grass and mulch slopes and ditches that will not be paved. Construct the ditch paving required in the affected area.
6. Keep the gate in place until the work in the affected drainage area is complete and the erodible area is stabilized.
7. Remove the Type 1 silt gate assembly by sawing off the wood posts flush with the concrete apron. Leave the concrete apron between the gate and the structure inlet in place. The gate shall remain the property of the Contractor.

B. Temporary Slope Drains

If temporary slope drains are required, conduct the roadway grading operation according to Section 161 and follow these guidelines:

1. Place temporary pipe slope drains with inlets and velocity dissipaters (straw bales, silt fence, or aprons) according to the Plans.
2. Securely anchor the inlet into the slope to provide a watertight connection to the earth berm. Ensure that all connections in the pipe are leak proof.
3. Place temporary slope drains at a spacing of 350 ft (105 m) maximum on a 0% to 2% grade and at a spacing of 200 ft (60m) maximum on steeper grades, or more frequently as directed by the Engineer. Keep the slope drains in place until the permanent grass has grown enough to control erosion.
4. Remove the slope drains and grass the disturbed area with permanent grass. However, the temporary slope drains may remain in place to help establish permanent grass if approved by the Engineer.

C. Temporary Sediment Basins

Construct temporary sediment basins according to the Plans at the required locations, or as modified by the Engineer.

1. Construct the unit complete as shown, including:
 - Grading
 - Drainage
 - Riprap
 - Spillways
 - Anti-seep collar
 - Temporary mulching and grassing on internal and external slopes
 - Accessories to complete the basin
2. When the sediment basin is no longer needed, remove and dispose of the remaining sediment.
3. Remove the sediment basin. Grade to drain and restore the area to blend with the adjacent landscape.
4. Mulch and permanently grass the disturbed areas according to Section 700.

D. Sediment Barriers

Construct sediment barriers according to the Plan details.

The following items may be used for sediment barriers

1. Type A Silt Fence.
2. Type C Silt Fence.
3. Rectangular, mechanically produced and standard-sized baled wheat straw.
4. Triangular Silt Barrier.
5. Synthetic Fiber: Use synthetic fiber bales of circular cross section at least 18 in (450 mm) in diameter. Use synthetic bales of 3 ft or 6 ft (0.9 m or 1.8 m) in length that are capable of being linked together to form a continuous roll of the desired total length. Use bales that are enclosed in a geotextile fabric and that contain a pre-made stake hole for anchoring.
6. Coir: Use coir fiber bales of circular cross section at least 16" (400mm) in diameter. Use coir bales of 10 ft, 15 ft, or 20 ft (3 m, 4.5 m, or 6 m) in length. Use coir baled with coir twine netting with 2 in X 2 in (50 mm X 50 mm) openings. Use coir bales with a dry density of at least 7 lb/ft³ (112 kg/m³). Anchor in place with 2 in X 4 in (50 mm X 100 mm) wooden wedges with a 6 in (150 mm) nail at the top. Place wedges no more than 36 in (900 mm) apart.
7. Excelsior: Use curled aspen excelsior fiber with barbed edges in circular bales of at least 18 in (450 mm) in diameter and nominally 10 ft (3 m) in length. Use excelsior baled with polyester netting with 1 in X 1 in (25 mm by 25 mm) triangular openings. Use excelsior bales with a dry density of at least 1.4 lb/ft³ (22 kg/m³). Anchor in place with 1 in (25 mm) diameter wooden stakes driven through the netting at intervals of no more than 2 ft (600 mm).
8. Compost Filter Sock: Use general use compost (see Subsection 893.2.02.A.5.b) in circular bales at least 18 in diameter. Use compost baled with photo-degradable plastic mesh 3 mils thick with a maximum 0.25 in X 0.25 in (6 mm X 6 mm) openings. Anchor in place with 1 in (25 mm) diameter wooden stakes driven through the netting at intervals of no more than 2 ft (600 mm). The sock shall be dispersed on site when no longer required, as determined by the Engineer. Do not use Compost Filter Socks in areas where the use of fertilizer is restricted.

9. Compost Filter Berm: Use erosion control compost (see Subsection 893.2.02) to construct a noncompacted 1.5 ft to 2 ft (450 mm to 600 mm) high trapezoidal berm which is approximately 2 ft to 3 ft (600 mm to 1 m) wide at the top and minimum 4 ft (1.2 m) wide at the base. Do not use Compost Filter Berms in areas where the use of fertilizer is restricted.

The construction of the compost filter berm includes the following:

- a. Keeping the berm in a functional condition.
- b. Installing additional berm material when necessary.
- c. Removing the berm when no longer required, as determined by the Engineer. At the Engineer's discretion, berm material may be left to decompose naturally, or distributed over the adjacent area.

E. Other Temporary Structures

When special conditions occur during the design stage, the Plans may show other temporary structures for erosion control with required materials and construction methods.

F. Temporary Grass

Use a quick-growing species of temporary grass such as rye grass, millet, or a cereal grass suitable to the area and season.

Use temporary grass in the following situations:

- When required by the Specifications or directed by the Engineer to control erosion where permanent grassing cannot be planted.
- To protect an area for longer than mulch is expected to last (60 calendar days), plant temporary grass as follows:
 1. Use seeds that conform to Subsection 890.2.01, "Seed." Perform seeding according to Section 700; except use the minimum ground preparation necessary to provide a seed bed if further grading is required.
 2. Prepare areas that require no further grading according to Subsection 700.3.05.A, "Ground Preparation." Omit the lime unless the area will be planted with permanent grass without further grading. In this case, apply the lime according to Section 700.
 3. Apply mixed grade fertilizer at 400 lbs/acre (450 kg/ha). Omit the nitrogen. Mulch (with straw or hay) temporary grass according to Section 700. (Erosion control compost Mulch will not be allowed with grassing.)
 4. Before planting permanent grass, thoroughly plow and prepare areas where temporary grass has been planted according to Subsection 700.3.05.A, "Ground Preparation".
 5. Apply Polyacrylamide (PAM) to all areas that receive temporary grassing.
 6. Apply PAM (powder) before grassing or PAM (emulsion) to the hydroseeding operation.
 7. Apply PAM according to manufacturer specifications.
 8. Use only anionic PAM.

For projects that consist of shoulder reconstruction and/or shoulder widening, refer to Section 161.3.05H for Wood Fiber Blanket requirements.

G. Mulch

When staged construction or other conditions prevent completing a roadway section continuously, apply mulch (straw or hay or erosion control compost) to control erosion. Mulch may be used without temporary grassing for 60 calendar days or less. Areas stabilized with only mulch (straw/hay) shall be planted with temporary grass after 60 calendar days.

Apply mulch as follows:

1. Mulch (Hay or Straw) - Without Grass Seed
 - a. Uniformly spread the mulch over the designated areas from 2 in to 4 in (50 mm to 100 mm) thick.
 - b. After spreading the mulch, walk in the mulch by using a tracked vehicle (preferred method), empty sheep foot roller, light disking, or other means that preserves the finished cross section of the prepared areas. The Engineer will approve of the method.
 - c. Place temporary mulch on slopes as steep as 2:1 by using a tracked vehicle to imbed the mulch into the slope.
 - d. When grassing operations begin, leave the mulch in place and plow the mulch into the soil during seed bed preparation. The mulch will become beneficial plant food for the newly planted grass.

2. Erosion control compost - Without Grass Seed
 - a. Uniformly spread the mulch (erosion control compost) over the designated areas 2 in (50 mm) thick.
 - b. When rolling is necessary, or directed by the Engineer, use a light corrugated drum roller.
 - c. When grassing operations begin, leave the mulch in place and plow the mulch into the soil during seed bed preparation. The mulch will become beneficial plant food for the newly planted grass.
 - d. Plant temporary grass on area stabilized with mulch (erosion control compost) after 60 calendar days.
 - e. Do not use Erosion Control Compost in areas where the use of fertilizer is restricted.

H. Miscellaneous Erosion Control Items Not Shown on the Plans

When conditions develop during construction that were unforeseen in the design stage, the Engineer may direct the Contractor to construct temporary devices such as but not limited to:

- Bulkheads
- Sump holes
- Half round pipe for use as ditch liners
- U-V resistant plastic sheets to cover critical cut slopes

The Engineer and the Contractor will determine the placement to ensure erosion control in the affected area.

I. Diversion Channels

When constructing a culvert or other drainage structure in a live stream that requires diverting a stream, construct a diversion channel.

J. Check Dams

Check dams are constructed of the following materials;

- Stone plain riprap according to Section 603 (Place woven plastic filter fabric on ditch section before placing riprap.)
- Sand bags as in Section 603 without Portland cement
- Baled wheat straw
- Compost filter socks
- Fabric (Type C silt fence)

Check dams shall be constructed according to plan details and shall remain in place until the permanent ditch protection is in place or being installed and the removal is approved by the Engineer.

K. Construction Exits

Locate construction exits at any point where vehicles will be leaving the project onto a public roadway. Install construction exits at the locations shown in the plans and in accordance with plan details.

L. Retrofits

Add the retrofit device to the permanent outlet structure as shown on the Plan details.

When all land disturbing activities that would contribute sediment-laden runoff to the basin are complete, clean the basin of sediment and stabilize the basin area with vegetation.

When the basin is stabilized, remove the retrofit device from the permanent outlet structure of the detention pond.

M. Inlet Sediment Traps

Inlet sediment traps consist of a temporary device placed around a storm drain inlet to trap sediment. An excavated area adjacent to the sediment trap will provide additional sediment storage.

Inlet sediment traps may be constructed of Type C silt fence, plastic frame and filter, hay bales, baffle box, or other filtering materials approved by the Engineer. Construct inlet sediment traps according to the appropriate specification for the material selected for the trap. Place inlet sediment traps as shown on the Plans or as directed by the Engineer.

N. Rock Filter Dams

Construct rock filter dams of the material selected as shown in the approved erosion and sediment control plan. Construct and place this item in accordance with the approved erosion control construction detail(s) and Standard Specification Section 603.

Rock filter dams shall remain in place until the permanent ditch protection is in place or is being installed and their removal is approved by the Engineer.

O. Stone Filter Berms

Construct stone filter berms of the material selected as shown in the approved erosion and sediment control plan. Construct and place this item in accordance with the approved erosion control construction detail(s) and Standard Specification Section 603.

Stone filter berms shall remain in place until the permanent slope protection is in place or is being installed and their removal is approved by the Engineer.

P. Stone Filter Rings

Construct stone filter rings of the material selected as shown in the approved erosion and sediment control plan. Construct and place this item in accordance with the approved erosion control construction detail(s) and Standard Specification Section 603.

A stone filter ring shall remain in place until final stabilization of the area which drains toward it is achieved and its removal is approved by the Engineer.

Q. Temporary Sediment Traps

Construct temporary sediment traps of the material selected as shown in the approved erosion and sediment control plan. Construct and place this item in accordance with the approved erosion control construction detail(s) and Standard Specification Section 603.

A temporary sediment trap shall remain in place until final stabilization of the area which drains toward it is achieved and its removal is approved by the Engineer.

163.3.06 Quality Acceptance

General Provisions 101 through 150.

163.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

163.4 Measurement

A. Silt Control Gates

Silt control gates are measured for payment by the entire structure constructed at each location complete in place and accepted. Silt control gates constructed at the inlet of multiple lines of drainage structures are measured for payment as a single unit.

B. Temporary Slope Drains

Temporary slope drains are measured for payment by the linear foot (meter) of pipe placed. When required, the inlet spillway and outlet apron and/or other dissipation devices are incidental and not measured separately.

C. Temporary Sediment Basins

Temporary sediment basins are measured for payment by the entire structure complete, including construction, maintenance, and removal. Temporary grassing for sediment basins is measured separately for payment. Measurement also includes:

- Earthwork
- Drainage
- Spillways
- Baffles
- Riprap
- Final cleaning to remove the basin

D. Sediment Barriers

Sediment barriers are measured by the linear foot (meter).

E. Other Temporary Structures

Other temporary structures are not measured for payment. Costs for the entire structure complete, including materials, construction (including earthwork), and removal is included in the price bid for the drainage structure or for other Contract items.

F. Temporary Grass

Temporary grass is measured for payment by the acre (hectare). Lime, when required, is measured by the ton (megagram). Mulch and fertilizer are measured separately for payment.

G. Mulch

Mulch (straw or hay, or erosion control compost) is measured for payment by the ton (megagram).

H. Miscellaneous Erosion Control Items Not Shown on the Plans

These items are not measured for payment. The cost for construction, materials, and removal is included in the price bid for other contract items.

I. Diversion Channels

Diversion channels are not measured for payment. The cost for the entire structure complete, including materials, construction (including earthwork), and removal is included in the price bid for the drainage structure or for other contract items.

J. Check Dams

Stone, sand bags, baled wheat straw, and compost filter sock check dams are measured per each, which includes all work necessary to construct the check dam including woven plastic filter fabric placed beneath stone check dams. Fabric check dams are measured per linear foot.

K. Construction Exits

Construction exits are measured per each which will include all work necessary to construct the exit including the required geotextile fabric placed beneath the aggregate.

L. Retrofits

Retrofit will be measured for payment per each. The construction of the detention pond and permanent outlet structure will be measured separately under the appropriate items.

M. Inlet Sediment Traps

Inlet sediment traps, regardless of the material selected, are measured per each which includes all work necessary to construct the trap including any incidentals and providing the excavated area for sediment storage.

N. Rock Filter Dams

Rock filter dams are measured for payment per each required. This includes the entire structure at each location and all the work necessary for construction.

O. Stone Filter Berms

Stone filter berms are measured for payment per linear foot (meter) required. This includes the entire structure at each location and all the work necessary for construction.

P. Stone Filter Rings

Stone filter rings are measured for payment per each required. This includes the entire structure at each location and all the work necessary for construction.

Q. Temporary Sediment Traps

Temporary sediment traps are measured for payment per each required. This includes the entire structure at each location and all the work necessary for construction.

163.4.01 Limits

General Provisions 101 through 150.

163.5 Payment

A. Silt Control Gates

The specified silt control gates are paid for at the Contract Unit Price per each. Payment is full compensation for:

- Furnishing the material and labor
- Constructing the concrete apron as shown on the Plans
- Excavating and backfilling to place the apron
- Removing the gate

B. Temporary Slope Drains

Temporary slope drains are paid for by the linear foot (meter). Payment is full compensation for materials, construction, removal (if required), inlet spillways, velocity dissipaters, and outlet aprons.

When temporary drain inlets and pipe slope drains are removed, they remain the Contractor's property and may be reused or removed from the Project as the Contractor desires. Reused pipe or inlets are paid for the same as new pipe or inlets.

C. Temporary Sediment Basins

Temporary sediment basins, measured according to Subsection 163.4,C "Measurement," are paid for by the unit, per each, for the type specified on the Plans. Price and payment are full compensation for work and supervision to construct, and remove the sediment basin, including final clean-up.

D. Sediment Barriers

Sediment barriers are paid by the linear foot (meter). Price and payment are full compensation for work and supervision to construct, and remove the sediment barrier, including final clean-up.

E. Other Temporary Structures

Other temporary structures are not measured for payment. Costs for the entire structure complete, including materials, construction (including earthwork), and removal is included in the price bid for the drainage structure or for other Contract items.

F. Temporary Grass

Temporary grass is paid for by the acre (hectare). Payment is full compensation for all equipment, labor, ground preparation, materials, wood fiber mulch, polyacrylamide, and other incidentals. Lime (when required) is paid for by the ton (megagram). Mulch and fertilizer are paid for separately.

G. Mulch

Mulch is paid for by the ton. Payment is full compensation for all materials, labor, maintenance, equipment and other incidentals.

The weight for payment of straw or hay mulch will be the product of the number of bales used and the average weight per bale as determined on certified scales provided by the contractor or state certified scales. Provide written documentation to the Engineer stating the average weight of the bales.

The weight of erosion control compost mulch will be determined by weighing each loaded vehicle on the required motor truck scale as the material is hauled to the roadway, or by using recorded weights if a digital recording device is used. The contractor may propose other methods of providing the weight of the mulch to Engineer for approval.

H. Miscellaneous Erosion Control Items Not Shown on the Plans

These items are not paid for separately. They are included in the price bid for other contract items.

I. Diversion Channel

Diversion channels are not paid for separately. They are included in the price bid for other contract items.

J. Check Dams

Payment is full compensation for all materials, construction, and removal. Stone plain riprap, sand bag, baled wheat straw, or compost filter socks check dams are paid for per each. The required woven filter fabric required under each stone check dams is included in the bid price. Fabric check dams are paid for per linear foot.

K. Construction Exits

Construction exits are paid for per each. Payment is full compensation for all materials including the required geotextile, construction, and removal.

L. Retrofits

This item is paid for at the Contract Unit Price per each. Payment is full compensation for all work, supervision, materials (including the stone filter), labor and equipment necessary to construct and remove the retrofit device from an existing or proposed detention pond outlet structure.

M. Inlet Sediment Traps

Inlet sediment traps are paid for per each. Payment is full compensation for all materials, construction, and removal.

N. Rock Filter Dams

Rock filter dams are paid for per each. Payment is full compensation for all materials, construction, and removal for each. Clean reused stone Type 3 riprap and #57 stone are paid for on the same basis as new items. Plastic woven filter fabric is required under rock filter dams and is included in the price bid for each.

O. Stone Filter Berms

Stone filter berms are paid for per linear foot (meter). Payment is full compensation for all materials, construction, and removal for each. Clean reused stone Type 3 riprap and #57 stone are paid for on the same basis as new items. Plastic woven filter fabric is required under rock filter berms and is included in the price bid for linear foot (meter).

P. Stone Filter Rings

Stone filter rings are paid for per each. Payment is full compensation for all materials, construction, and removal for each. Clean reused stone Type 3 riprap and #57 stone are paid for on the same basis as new items. Plastic woven filter fabric is required under stone filter rings and is included in the price bid for each.

Q. Temporary Sediment Traps

Temporary sediment traps are paid for payment per each required. This includes the entire structure at each location and all the work necessary for construction.

The items in this section (except temporary grass and mulch) are made as partial payments as follows:

- When the item is installed and put into operation the Contractor will be paid 75 percent of the Contract price.
- When the Engineer instructs the Contractor that the item is no longer required and is to remain in place or is removed, whichever applies, the remaining 25 percent will be paid.

Temporary devices may be left in place at the Engineer's discretion at no change in cost. Payment for temporary grass will be made based on the number of acres (hectares) grassed. Mulch will be based on the number of tons (megagrams) used.

Payment is made under:

Item No. 163	Construct and remove silt control gates	Per each
Item No. 163	Construct and remove temporary pipe slope drains	Per linear foot (meter)
Item No. 163	Construct and remove temporary sediment barriers	Per linear foot (meter)
Item No. 163	Construct and remove sediment basins	Per each
Item No. 163	Construct and remove check dams except fabric dams	Per each
Item No. 163	Construct and remove fabric check dams	Per linear foot (meter)
Item No. 163	Construct and remove construction exits	Per each
Item No. 163	Construct and remove retrofits	Per each
Item No. 163	Construct and remove rock filter dams	Per each
Item No. 163	Construct and remove stone filter berms	Per linear foot (meter)
Item No. 163	Construct and remove stone filter rings	Per each
Item No. 163	Construct and remove inlet sediment traps	Per each
Item No. 163	Construct and remove temporary sediment traps	Per each
Item No. 163	Temporary grass	Per acre (hectare)
Item No. 163	Mulch	Per ton (megagram)

163.5.01 Adjustments

General Provisions 101 through 150.

Section 165—Maintenance of Temporary Erosion and Sedimentation Control Devices

Delete Section 165 and substitute the following:

165.1 General Description

This work consists of providing maintenance on temporary erosion and sediment control devices, including but not limited to the following:

- Silt control gates
- Temporary erosion control slope drains shown on the Plans or as directed
- Temporary sediment basins
- Silt control gates
- Check dams
- Sediment barriers
- Rock filter dams
- Stone filter berms
- Stone filter rings
- Temporary sediment traps

It also consists of removing sediment that has accumulated at the temporary erosion and sedimentation control devices.

165.1.01 Definitions

General Provisions 101 through 150.

165.1.02 Related References

A. Standard Specifications

General Provisions 101 through 150.

B. Referenced Documents

General Provisions 101 through 150.

165.1.03 Submittals

General Provisions 101 through 150

165.2 Materials

General Provisions 101 through 150.

165.2.01 Delivery, Storage, and Handling

General Provisions 101 through 150.

165.3 Construction Requirements

165.3.01 Personnel

General Provisions 101 through 150.

165.3.02 Equipment

General Provisions 101 through 150.

165.3.03 Preparation

General Provisions 101 through 150.

165.3.04 Fabrication

General Provisions 101 through 150.

165.3.05 Construction

As a minimum, clean sediment from all temporary erosion control devices (except temporary sediment basins) installed on the project when one-half the capacity by volume, as measured by depth, has been reached. Clean sediment from all temporary sediment basins installed on a project when one-third the capacity of the storage volume has been filled.

Handle excavated sediment from any erosion or sediment control device in one of the following ways:

- Remove sediment from the immediate area and immediately stabilize it to prevent the material from refilling any erosion or sediment control device.
- Place and mix it in the roadway embankment or waste it in an area approved by the Engineer.

Repair or replace at no cost to the Department any erosion or sediment control device that is not functioning properly or is damaged due to negligence or abuse.

A. Temporary Silt Fence

Maintenance of temporary silt fence consists of furnishing all labor, tools, materials, equipment and necessary incidentals to remove and dispose of accumulated sediment down to the original ground line (0 % filled). Also included is the removal of sediment accumulations ("filtercake") on the fabric by tapping the fabric on the downstream side.

B. Silt Control Gates

Maintenance of temporary silt control gates consists of all labor, tools, materials, equipment and necessary incidentals to remove and dispose of accumulated sediment down to the original ground line (0% filled). When applicable, this item will include the removal of sediment accumulations on the fabric by tapping the fabric on the downstream side.

C. Check Dams (all types)

Maintenance of temporary erosion control check dams shall consist of all labor, tools, materials, equipment and necessary incidentals to remove and dispose of accumulated sediment down to the original ground line (0% filled). This item also includes the removal of any material deposited in sump holes. When applicable, this item will include the removal of sediment accumulations on the fabric by tapping the fabric on the downstream side, or from the baled straw by similar means.

D. Silt Retention Barriers

Maintenance of temporary silt retention barriers consists of all labor, tools, materials, equipment and necessary incidentals to remove and dispose of accumulated sediment down to the original ground line (0% filled).

E. Temporary Sediment Basins

Maintenance of temporary sediment basins consists of all labor, tools, materials, equipment and necessary incidentals to remove and dispose of accumulated sediment down to the original bottom of the basin. This also includes removing accumulated sediment from the rock filter and restoring the rock filter to its original specified condition and any work necessary to restore all other components to the pre-maintenance conditions.

F. Sediment Barriers

Maintenance of sediment barriers consists of furnishing all labor, tools, materials, equipment and necessary incidentals to remove and dispose of accumulated sediment down to the original ground line (0 % filled). Also included is the removal of sediment accumulations on the barriers by tapping.

G. Triangular Silt Barriers

Maintenance of triangular silt barriers consists of all labor, tools, materials, equipment and necessary incidentals to remove and dispose of accumulated sediment down to the original ground line (0% filled).

H. Retrofits

Maintenance of the retrofits device consists of all labor, tools, materials, equipment and necessary incidentals to remove and properly dispose of accumulated sediment in the permanent detention pond being utilized as a temporary sediment basin. This item also includes any maintenance that is required to ensure the retrofit device is maintained per Plan details and any maintenance of the stone filter to maintain its filtering ability, including cleaning and replacement.

I. Construction Exits

Maintenance of the construction exits consists of all labor, tools, materials, equipment and incidentals, including additional stone and geotextile fabric as required to prevent the tracking or flow of soil onto public roadways. This includes scarifying existing stone, cleaning existing stone, or placement of additional stone.

Cleaning of the construction exit by scraping and/or brooming only will not be measured for payment.

J. Inlet Sediment Traps

Maintenance of inlet sediment traps consists of all labor, tools, materials, equipment, and necessary incidentals to remove and properly dispose of accumulated sediment in the trap and/or the excavated area adjacent to the trap. It also includes any maintenance that is required to remove sediment accumulations (“filtercake”) from the material selected to construct the inlet sediment trap.

K. Rock Filter Dams

Maintenance of rock filter dams consists of all labor, tools, materials, equipment, and necessary incidentals to remove and dispose of accumulated sediment down to the original ground line (0% filled). This item also includes the removal of any material deposited in sump holes.

L. Stone Filter Berms

Maintenance of stone filter berms consists of all labor, tools, materials, equipment, and necessary incidentals to remove and dispose of accumulated sediment down to the original ground line (0% filled). This item also includes the removal of any material deposited in sump holes.

M. Stone Filter Rings

Maintenance of stone filter rings consists of all labor, tools, materials, equipment, and necessary incidentals to remove and dispose of accumulated sediment down to the original ground line (0% filled). This item also includes the removal of any material deposited in sump holes.

N. Temporary Sediment Traps

Maintenance of temporary sediment traps consists of all labor, tools, materials, equipment, and necessary incidentals to remove and dispose of accumulated sediment down to the original ground line (0% filled). This item also includes the removal of any material deposited in sump holes.

165.3.06 Quality Acceptance

General Provisions 101 through 150.

165.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

165.4 Measurement

A. Temporary Silt Fence

Maintenance of temporary silt fence, Type A or C, is the actual linear feet (meter) of silt fence measured in place where sediment is removed.

B. Silt Control Gates

Maintenance of temporary silt control gates, Type I, II, or III, as specified on the Plans is measured as a single unit.

C. Check Dams (All Types)

Maintenance of temporary erosion control check dams as specified on the Plans is the actual linear feet (meter) of baled straw, or rip rap, measured in place, where sediment is removed.

D. Silt Retention Barriers

Maintenance of temporary silt retention barrier as specified on the Plans is measured by the linear foot (meter) where sediment is removed.

E. Temporary Sediment Basins

Maintenance of temporary sediment basins as specified on the Plans is measured as a single unit.

F. Sediment Barriers

Maintenance of sediment barriers is the actual linear feet (meter) measured in place where sediment is removed.

G. Triangular Silt Barriers

Maintenance of triangular silt barrier as specified on the plans is measured by the linear foot (meter) where sediment is removed.

H. Retrofits

Maintenance of retrofit devices at the location specified on the Plans is measured per each.

I. Construction Exits

Maintenance of construction exits at the location specified on the Plans, or as directed by the Engineer is measured per each.

J. Inlet Sediment Traps

Maintenance of inlet sediment traps at the location specified on the Plans, or as added by the Engineer is measured per each.

K. Rock Filter Dams

Maintenance of rock filter dams as specified on the plans is measured as a single unit.

L. Stone Filter Berms

Maintenance of stone filter berms as specified on the plans is measured per linear foot (meter).

M. Stone Filter Rings

Maintenance of stone filter rings as specified on the plans is measured as a single unit.

N. Temporary Sediment Traps

Maintenance of temporary sediment traps as specified on the plans is measured as a single unit.

165.4.01 Limits

General Provisions 101 through 150.

165.5 Payment

A. Temporary Silt Fence

Maintenance of temporary silt fence, Type A or C, is paid for at the contract unit price bid per linear foot (meter).

B. Silt Control Gates

Maintenance of temporary silt control gates, Type I, II, or III, as specified on the Plans is paid for at the contract unit price bid per each.

C. Check Dams

Maintenance of check dams as specified on the Plans is paid for at the contract unit price bid per linear foot (meter).

D. Silt Retention Barriers

Maintenance of temporary silt retention barriers as specified on the Plans is paid for at the contract unit price bid per linear foot (meter).

E. Temporary Sediment Basins

Maintenance of temporary sediment basins as specified on the Plans is paid for at the contract unit price bid per each.

F. Sediment Barriers

Maintenance of sediment barriers as specified on the Plans is paid for at the contract unit price bid per linear foot (meter).

G. Triangular Silt Barriers

Maintenance of triangular silt barriers as specified on the Plans is paid for at the contract unit price bid per linear foot (meter).

H. Retrofits

Maintenance of the retrofit devices at the location specified on the Plans is paid for at the contract unit price bid per each.

I. Construction Exits

Maintenance of the construction exits at the location specified on the Plans or as added by the Engineer is paid for at the contract unit price per each.

J. Inlet Sediment Traps

Maintenance of the inlet sediment traps at the location specified on the Plans or at the location specified by the Engineer is paid for at the contract unit price per each.

K. Rock Filter Dams

Maintenance of rock filter dams as specified on the Plans is paid for at the contract unit price bid per each.

L. Stone Filter Berms

Maintenance of stone filter berms as specified on the Plans is paid for at the contract unit price bid per linear foot (meter).

M. Stone Filter Rings

Maintenance of stone filter rings as specified on the Plans is paid for at the contract unit price bid per each.

N. Temporary Sediment Traps

Maintenance of temporary sediment traps as specified on the Plans is paid for at the contract unit price bid per each.

Payment will be made under:

Item No. 165	Maintenance of temporary silt fence	per linear foot (meter)
Item No. 165	Maintenance of silt control gates	per each
Item No. 165	Maintenance of check dams	per linear foot (meter)
Item No. 165	Maintenance of silt retention barriers	per foot (meter)
Item No. 165	Maintenance of temporary sediment basins	per each
Item No. 165	Maintenance of sediment barriers	per linear foot (meter)
Item No. 165	Maintenance of triangular silt barriers	per linear foot (meter)
Item No. 165	Maintenance of retrofits	per each
Item No. 165	Maintenance of construction exits	per each
Item No. 165	Maintenance of inlet sediment traps	per each
Item No. 165	Maintenance of rock filter dams	per each
Item No. 165	Maintenance of stone filter berms	per linear foot (meter)
Item No. 165	Maintenance of rock filter dams	per each
Item No. 165	Maintenance of temporary sediment traps	per each

165.5.01 Adjustments

General Provisions 101 through 150.

Section 167—Water Quality Monitoring

Delete Section 167 and substitute the following:

167.1 General Description

This Specification establishes the Contractor’s responsibility to meet the requirements of the National Pollutant Discharge Elimination System (NPDES) Infrastructure Permit No. GAR 100002 as it pertains to Part IV. Erosion, Sedimentation and Pollution Control Plan. In the case of differing requirements between this specification and the Permit, whichever is the more stringent requirement shall be adhered to.

167.1.01 Definitions

Certified Personnel— certified personnel are defined as persons who have successfully completed the appropriate certification course approved by the Georgia Soil and Water Conservation Commission. For Department projects the certified person must also have successfully completed the Department’s WECS certification course.

Water Quality Sampling – as used within this specification, the term “monitoring” shall be inclusive of the acts of detecting, noting, discerning, observing, etc. for the purpose of gauging compliance with the NPDES General Permit GAR100002.

Qualifying Rainfall Sampling Event—as used within this specification, means that which is defined in the 2013 NPDES General Permit GAR1000002, Part IV.D.6.d(3).

167.1.02 Related References

A. Standard Specifications

Section 161—Control of Soil Erosion and Sedimentation

B. Referenced Documents

NPDES Infrastructure Permit No. GAR100002

GDOT WECS seminar.

Environmental Protection Divisions Rules and Regulations (Chapter 391-3-26) Georgia Soil and Water Conservation Commission

Certification Level IA course. OCGA 12-7

167.1.03 Submittals

General Provisions 101 through 150

167.2 Materials

General Provisions 101 through 150.

167.2.01 Delivery, Storage, and Handling

General Provisions 101 through 150.

167.3 Construction Requirements

167.3.01 Personnel

Use GASWCC level IA certified and WECS certified personnel to perform all monitoring, sampling, inspections, and rainfall data collection.

Use the Contractor-designated WECS or select a prequalified consultant from the Qualified Consultant List (QCL) to perform water quality monitoring, sampling, inspections, and rainfall data collection.

The Contractor is responsible for having a copy of the GAR100002 Permit onsite at all times.

167.3.02 Equipment

Provide equipment necessary to complete the Work or as directed.

167.3.03 Preparation

General Provisions 101 through 150.

167.3.04 Fabrication

General Provisions 101 through 150.

167.3.05 Construction

A. General

Perform inspections, rainfall data collection, testing of samples, and reporting the test results on the project according to the requirements in Part IV of the NPDES Infrastructure Permit and this Specification. Take samples manually or use automatic samplers, according to the GAR100002 Permit GAR100002. Note that GAR100002 requires the use of manual sampling or rising stage sampling for qualifying events that occur after the first instance of the automatic sampler not being activated during a qualifying event. Analyze all samples according to the Permit, regardless of the method used to collect the samples. If samples are analyzed in the field using portable turbidimeters, the monitoring results shall state they are being used and a digital readout of NTUs is what is provided. Submit bench sheets, work sheets, etc., when using portable turbidimeters. There are no exceptions to this requirement. Perform required inspections and submit all reports required by this Specification within the time frames specified. Failure to perform the inspections within the time specified will result in the cessation of all construction activities with the exception of traffic control and erosion control. Failure to submit the required reports within the times specified will result in non-refundable deductions as specified in Subsection 161.5.01.B.

B. Water Quality Inspections

The Department will provide one copy of the required inspection forms for use and duplication. Inspection forms may change during the contract to reflect regulatory agency needs or the need of the Department. Any costs associated with the change of inspection forms shall be considered incidental. Alternate formats of the provided forms may be created, used and submitted by the Contractor provided the required content and/or data fields and verbatim certification statements from the Department's current forms are included.

The Engineer shall inspect the installation and condition of each erosion control device required by the erosion control plan within seven days after initial installation. This inspection is performed for each stage of construction when new devices are installed. The WECS shall ensure all installation deficiencies reported by the Engineer are corrected within two business days.

Ensure the inspections of the areas listed below are conducted by certified personnel and at the frequencies listed. Document all inspections on the appropriate form provided by the Department.

1. Daily (when any work is occurring):

- a. Petroleum product storage, usage and handling areas for spills or leaks from vehicles or equipment.
- b. All locations where vehicles enter/exit the site for evidence of off-site sediment tracking.

Continue these inspections until a Notice of Termination (NOT) is submitted and use the daily inspection forms.

2. Weekly and after Rainfall Events:

Conduct inspections on these areas every seven calendar days and within twenty-four hours after the end of a rainfall event that is 0.5 in (13 mm) or greater (unless such storm ends after 5:00 PM on any Friday or any non-working Saturday, non-working Sunday or any non-working Federal holiday in which case the inspection shall be completed by the end of the next business day and/or working day, whichever occurs first):

- a. Disturbed areas not permanently stabilized
- b. Material storage areas that are exposed to precipitation
- c. Structural control measures, Best Management Practices (BMPs) to ensure they are operating correctly.
- d. Water quality sampling locations and equipment
- e. Discharge locations or points, e.g., outfalls and drainage structures that are accessible to determine if erosion control measures are effective in preventing significant impacts to receiving waters.

Continue these inspections until all temporary BMPs are removed and a NOT is submitted and use the EC-1 Form.

3. Monthly:

Once per month, inspect all areas where final stabilization has been completed. Look for evidence of sediments or pollutants entering the drainage system and or receiving waters. Inspect all permanent erosion control devices remaining in place to verify the maintenance status and that the devices are functioning properly. Inspect discharge locations or points, e.g. outfalls, drainage structures, that are accessible to determine if erosion control measures are effective in preventing significant impacts to receiving waters.

Continue these inspections until the Notice of Termination is submitted and use the monthly inspection form.

C. Water Quality Sampling

When the sampling location is a receiving water, the upstream and downstream samples are taken for comparison of NTU values. When the sampling location is an outfall, a single sample is taken to be analyzed for its absolute NTU value.

D. Reports

1. Inspection Reports:

Summarize the results of inspections noted above in writing on the appropriate Daily, Weekly, Monthly, or EC-1 form provided by the Department and includes the following information:

- Date(s) of inspection
- Name of certified personnel performing inspection
- Construction phase
- Status of devices
- Observations
- Action taken in accordance with Part IV.D.4.a.(5) of the GAR100002 Permit
- Signature of personnel performing the inspection
- Any instance of non-compliance

When the report does not identify any non-compliance instances, the inspection report shall contain a statement that the best management practices are in compliance with the Erosion, Sedimentation and Pollution Control Plan. (See the EC-1 form.)

The reports shall be made and retained at the site or be readily available at a designated alternate location until the entire site or that portion of a construction project that has been phased has undergone final stabilization and a Notice of Termination is submitted to the Georgia Department of Natural Resources Environmental Protection Division (GAEPD). Such reports shall be readily available by the end of the second business day and/or working day and shall identify all incidents of best management practices that have not been properly installed and/or maintained as described in the Plan. The inspection form certification sheet shall be signed by the project WECS and the inspector performing inspections on behalf of the WECS (if not the same person). Submit all inspection reports to the Engineer within twenty-four hours of the inspection. The Engineer will review the submitted reports to determine their accuracy. The Engineer will notify the certified personnel of any additional items that should be added to the inspection report.

Correct any items listed in the inspection report requiring routine maintenance within seventy-two (72) hours of notification or immediately during perimeter BMP failure emergencies. Deficiencies that interfere with traffic flow, safety, or downstream turbidity are to be corrected immediately.

Assume responsibility for all costs associated with additional sampling as specified in Part IV.D.6.d.3.(c) of the NPDES GAR100002 Permit if either of these conditions arise:

- BMPs shown in the Plans are not properly installed and maintained, or
- BMPs designed by the Contractor are not properly designed, installed and maintained.

2. Sampling Reports

a. All sampling shall be performed in accordance with the requirements of the GAR100002 Permit for the locations identified in the ESPCP approved by the Department.

b. Report Requirements

Include in all reports, the following certification statement, signed by the WECS or consultant providing sampling on the project:

“I certify under penalty of law that this report and all attachments were prepared under my direct supervision in accordance with a system designed to assure that certified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.”

When a rainfall event requires a sample to be taken, submit a report of the sampling results to the Engineer within seven working days of the date the sample was obtained. Include the following information in each report:

- 1) Date and time of sampling
- 2) Name of certified person(s) who performed the sampling and analyses.
- 3) Date the analyses were performed
- 4) Time the analyses were initiated
- 4) Rainfall amount on the sampling date (sampling date only)
- 5) NTU of each sample & analytical method
- 6) Location where each sample was taken (station number and left or right offset)
- 7) Identification of whether a sample is a receiving-water sample or an outfall sample

- 8) Project number and county
- 9) Whether the samples were taken by automatic sampler, rising-stage sampler, or manually (grab sample)
- 10) A clear note if a sample exceeds 1000 NTUs by writing “exceeds 1000 NTUs” prominently upon the report.

b. Report Requirements with No Qualifying Rainfall Events

In the event a qualifying rainfall event does not produce a discharge to sample, or sampling is “impossible”, as defined in the GAR1000002 Permit, a written justification must be included in the report as required at Part IV.D.4.a.(6) of the GAR100002 Permit.

c. Sampling Results

Provide sampling results to the Project Engineer within 48 hours of the samples being analyzed. This notification may be verbal or written. This notification does not replace the requirement to submit the formal summary to the Engineer within 7 working days of the samples being collected. The Engineer will ensure submission of the sampling report to GAEPD by the 15th of the month following the sampling results as per the GAR100002 Permit. The WECS will be held accountable for delayed delivery to the Department which results in late submissions to EPD resulting in enforcement actions.

3. Rainfall Data Reports:

Record the measurement of rainfall once each twenty-four hour period, except for non-working Saturdays, non-working Sundays and non-working Federal Holidays until a Notice of Termination is submitted. Project rain gauges and those used to trigger the automatic samplers are to be emptied after every rainfall event. This will prevent a cumulative effect and prevent automatic samplers from taking samples even though the rainfall event is not a qualifying event. The daily rainfall data supplied by the WECS to the Engineer will be the official rainfall data for the project.

167.3.06 Quality Acceptance

General Provisions 101 through 150.

167.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

167.4 Measurement

Water Quality Inspections in accordance with the inspection and reports sub-sections will be measured for payment by the month up to the time the Contract Time expires. Required inspections and reports after Contract Time has expired will not be measured for payment unless a time extension is granted.

Water Quality Sampling is measured per each. “Each” means each qualifying rainfall sampling event, not each sampled site.

167.4.01 Limits

General Provisions 101 through 150. Submit the monitoring summary report to the Engineer within 7 working days

167.5 Payment

Payment for Water Quality Inspections and Water Quality Sampling will be made as follows:

Water Quality Inspections will be paid at the Contract Price per month. This is full compensation for performing the requirements of the inspection section of the NPDES Permit and this Specification, any and all necessary incidentals, and providing results of inspections to the Engineer, within the time frame required by the NPDES Infrastructure Permit, and this Specification.

Water Quality Monitoring and Sampling per each qualifying rainfall sampling event is full compensation for meeting the requirements of the monitoring sections of the NPDES Permit and this Specification, obtaining samples, analyzing samples, any and all necessary incidentals, and providing results of turbidity tests to the Engineer, within the time frame required by the NPDES Infrastructure Permit, and this Specification. This item is based on the rainfall events requiring sampling as described in Part IV.D. 6 of the Permit. The Department will not pay for samples taken and analyzed for rainfall events that are not qualifying events as compared to the daily rainfall data supplied by the WECS.

Payment will be made under:

Item No. 167	Water quality inspections	Per month
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Water Quality Monitoring and Sampling will be paid per each qualifying rainfall sampling event.

Payment will be made under:

Item No. 167	Water quality monitoring and sampling	Per each
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167.5.01 Adjustments

General Provisions 101 through 150.

Section 206 – Borrow Excavation

Delete Subsection 206 and Substitute the following:

206.1 General Description

This work includes:

- Excavating material from borrow areas or pits outside the Project Right-of-Way
- Hauling and using the material as required on the Plans or directed by the Engineer
- Stripping, excavating, and disposing of unsuitable material from borrow areas. See Subsection 107.22 and Subsection 107.23

206.1.01 Definitions

General Provisions 101 through 150.

206.1.02 Related References

A. Standard Specifications

Section 106—Control of Materials

Section 107—Legal Regulations and Responsibility to the Public Section 160—Reclamation of Material Pits and Waste Areas Section 201—Clearing and Grubbing Right-of-Way

Section 202—Random Clearing and Grubbing

Section 208—Embankments

Section 209—Subgrade Construction

206.1.03 Submittals

The Engineer's approval of borrow pits will be subject to the requirements of Subsection 107.23.C – Environmental Clearance of Local Material or Disposal Sites.

Give the Engineer sufficient notice to perform necessary investigations, measurements, staking, and actions required in Subsection 206.3.05.A and Subsection 107.23.C.

Working in the pit before receiving the following approvals may result in rejection of the borrow pit without payment:

- Approval for environmental considerations and material acceptability
- Approval from pit investigation, cross sectioning, and staking

206.2 Materials

Perform work using embankment materials that meet the requirements in Section 208. Do not use material that contains roots or stumps. The Engineer will approve borrow excavation materials.

Use selected borrow of Class IIB3 or better when specified for subgrade construction or other uses (unless otherwise stated in the Plans or the Proposal).

206.2.01 Delivery, Storage, and Handling

Before obtaining material from borrow areas, use material to construct the embankment that is excavated from within the slope stakes, or stockpile the material for topping out the roadbed (unless otherwise directed by the Engineer).

206.3 Construction Requirements

206.3.01 Personnel

General Provisions 101 through 150.

206.3.02 Equipment

Ensure that equipment and methods used in borrow pits produce the following results:

- Various strata, pockets, or accumulations of different types of material are excavated and used in the correct proportions and sequence.
- Material is used to produce borrow or selected borrow with the best possible gradation and stability within the specified range.
- Material is excavated uniformly to facilitate measurement.

206.3.03 Preparation

General Provisions 101 through 150.

206.3.04 Fabrication

General Provisions 101 through 150.

206.3.05 Construction

A. General

The Department will investigate and take necessary actions to satisfy requirements of Section 106 of the National Historical Preservation Act.

B. Clearing and Grubbing

Clear and grub borrow pits as necessary before removing borrow material as specified in Section 106 and Section 202.

C. Draining Pits

Prevent water from standing in the pits unless the Engineer determines not to drain the pit.

Leave slopes presentable. Machine slope the bottom of the excavated area to smooth the surfaces suitable for revegetation.

The Department will not measure for payment ditch excavation for draining borrow pits. The bid price for borrow excavation shall include this work.

D. Disposing of Waste Material

Dispose of material unsuitable for embankments such as stone, broken rock, boulders, and other material found in the borrow pits.

1. Dispose of the material in a manner satisfactory to the Engineer and at no expense to the Department.
2. Do not leave piles of unsightly material in pits with or without the consent of the property owner.
3. Dispose of waste materials according to Subsection 201.3.05.E.

E. Reclamation

Leave borrow pits or waste disposal areas presentable. Reclaim them according to Section 160 unless exempted by Subsection 160.1.

Develop boundary slopes of reclaimed areas and grade them to 3:1 slopes or flatter.

206.3.06 Quality Acceptance

General Provisions 101 through 150.

206.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

206.4 Measurement

The quantity of borrow and selected borrow is measured in its original position by the method of average end areas or other

acceptable means.

When designated in the Plans, selected borrow may be measured by volume of the hauling vehicle according to Section 109.

The following will have no payment:

- Material excavated before the original surface of the pit is obtained by the Engineer
- Materials excavated for maintaining the work
- Materials excavated that run out of the embankment on a flatter slope than indicated on the cross-section shown on the Plans or established by the Engineer
- Unsuitable material excavated from the borrow area and not used on the roadway

The Department will measure original and final ground surfaces by conventional field or photogrammetric or other methods, as determined by the Engineer.

206.4.01 Limits

General Provisions 101 through 150.

206.5 Payment

The provisions of Section 106 apply to borrow pits. The Department will not pay for the following:

- Delays caused by fulfilling the requirements of Section 106 or costs involved if the borrow pit is rejected
- Work done to provide or improve access or haul roads to borrow pits (except when specifically stated in the Proposal)

The prices bid for borrow excavation shall include this cost.

The quantities of borrow and selected borrow are measured as described in Subsection 206.4 and will be paid for at the Contract Price per cubic yard (meter). This is full compensation for excavating, hauling, placing, and compacting the material according to the Plans and Specifications and for draining and dressing the borrow area.

Borrow material furnished at no cost (no royalty) to the Contractor is “borrow excavation.”

If royalties must be paid for material shown on the Plans as a possible source of borrow, or if the source of borrow must be furnished, the Bid Item is “borrow excavation including material.”

The same criteria applies to selected borrow.

Payment will be made under:

Item No. 206	Borrow excavation	Per cubic yard (meter)
Item No. 206	Borrow excavation, including material	Per cubic yard (meter)
Item No. 206	Selected borrow excavation	Per cubic yard (meter)
Item No. 206	Selected borrow excavation, including material	Per cubic yard (meter)

206.5.01 Adjustments

General Provisions 101 through 150.

Section 207—Excavation and Backfill for Minor Structures

Delete Section 207 and substitute the following:

207.1 General Description

This work includes excavating, backfilling, or disposing of materials required to install a bridge culvert, box culvert, pipe, arch culvert, headwall and retaining wall according to the Specifications, the Plans, and the Engineer.

207.1.01 Definitions

General Provisions 101 through 150.

207.1.02 Related References

A. Standard Specifications

Section 104—Scope of Work

Section 109—Measurement and Payment

Section 205—Roadway Excavation

Section 206—Borrow Excavation

Section 208—Embankments

Section 810—Roadway Materials

Section 812—Backfill Materials

B. Referenced Documents

GDT 7

207.1.03 Submittals

General Provisions 101 through 150.

207.2 Materials

Ensure that materials meet the requirements of the following Specifications:

Material	Section
Foundation Backfill Material—Type I	Subsection 812.2.01
Foundation Backfill Material—Type II	Subsection 812.2.02
Imperfect Trench Backfill Material—Type III	Subsection 812.2.03
Graded Aggregate Material	Subsection 815.2.01

207.2.01 Delivery, Storage, and Handling

General Provisions 101 through 150.

207.3 Construction Requirements

207.3.01 Personnel

General Provisions 101 through 150.

207.3.02 Equipment

General Provisions 101 through 150.

207.3.03 Preparation

General Provisions 101 through 150.

207.3.04 Fabrication

General Provisions 101 through 150.

207.3.05 Construction

A. Locations and Elevations

The Engineer will determine final locations and elevations of the structure. The locations and elevations shown on the Plans are approximate.

B. Excavation

The Engineer will determine the minimum requirements for length and depth of excavation for each structure. Assume the responsibility for the cost of installing necessary sheeting and bracing.

When excavating, follow these requirements:

- Excavate through rock or boulder formations to at least 1 ft (300 mm) below the bottom of the structure, except for where the entire concrete or masonry structure rests on solid rock.
- Backfill with Type I or Type II material to the proper subgrade elevation.
- As the embankment is constructed, excavate and place pipe on the new embankment. Pipe may be placed incrementally on steep gradients.
- Cut surfaces at structure trenches to prevent damage to the adjacent pavement when existing paved areas will be retained.
- Saw pavements deep enough to cause the edges to break in straight lines.
- Ensure that the width, depth, and vertical walls of an excavated imperfect trench conform to Plan details and dimensions within 2 in (50 mm).
- Dispose of surplus and unsuitable materials as directed by the Engineer.
- Consider excavated material as unclassified excavation according to Section 205, except that the Department will not pay for excavation for minor structures.
- Include the cost of fulfilling these requirements in the price bid for the pipe.

C. Backfill

Obtain backfill materials that meet the Specifications from sources approved by the Engineer.

1. Foundation Backfill Materials, Types I and II

Use the following materials as shown on the Plans or as directed by the Engineer:

- a. Use Type I material in dry structure trenches and Type II material in wet trenches.
- b. Use Type I material as a finishing course for Type II material when permitted by the Engineer.
- c. Backfill excavations beyond the specified limits with the same type of material required for the adjacent area; however, the Department will not measure excess backfill material for payment.
- d. Place Type I and Type II backfill material in layers of no more than 6 in (150 mm) loose.
- e. Compact each layer as follows:
 - 1) Type I Backfill Material: Compact to 95 percent of the theoretical dry density determined by GDT 7.
 - 2) Type II Backfill Material: Compact to a satisfactory uniform density as directed by the Engineer.

2. Imperfect Trench Backfill Material, Type III

Place this material as loose uncompacted backfill over pipe structures as shown on the Plans where imperfect trench backfill is specified.

3. Normal Backfill

Ensure that normal backfill material meets the requirements of Subsection 810.2.01, Class I or II. Class IIC1 material may be used in Districts 1, 6, and 7. Class IIC2 or IIC3 material may only be used in Districts 1, 6, and 7 if approved by the Office of Materials and Testing, Geotechnical Environmental Pavement Bureau. Place and compact according to Section 208 except as follows:

- a. Do not place rock more than 4 inches (100 mm) in diameter within 2 ft (600 mm) of any drainage structure.
- b. For backfill behind retaining walls, use a pervious material that meets the requirements of Case I or Case II as follows:
 - 1) Case I. Case I refers to backfills for retaining walls that support roadbeds and parking areas.
Ensure that the backfill conforms to Section 208. Do not place rock more than 4 in (100 mm) in diameter within 2 ft (600 mm) of the retaining wall or finished surface.
 - 2) Case II. Case II refers to backfills for retaining walls that do not support roadbeds or parking areas.
Ensure that the backfill conforms to the requirements of Case I above, except compact the backfill to the density of the adjacent soil.

4. Graded Aggregate Material

Ensure graded aggregate material meets the requirements of 815.2.01. Place and compact according to Section 208 except as follows:

- a. Backfill excavations beyond the specified limits with the same type of material required for the adjacent area; however, the Department will not measure excess backfill material for payment.
- b. Place aggregate backfill material in layers of no more than 8 inches (200 mm) loose
- c. Compact to 95 percent of the theoretical dry density determined by GDT 7

D. Construction Vehicle and Equipment Traffic

1. Care shall be taken at all times to protect pipe installations from damage, including but not limited to that arising from construction equipment and vehicles driving over completed installations prior to base construction.
2. For thermoplastic pipe installations a minimum cover of 2' shall be provided over any completed installation subject to construction vehicle and equipment loads prior to allowing them to be crossed by same.

E. Pavement Replaced

Replace pavement removed at structure trenches in kind where adjacent pavements will be retained. An equal or better material may be used when approved by the Engineer.

Backfill and maintain a smooth riding surface until repaving is complete.

207.3.06 Quality Acceptance

General Provisions 101 through 150.

207.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

207.4 Measurement

A. Excavation

The following considerations are not measured for payment:

- Excavation for minor structures, including undercut for backfill materials as shown on the Plans
- Excavation for an imperfect trench which is required at locations specified in the Plans but which is not measured for payment
- Removal of water
- Removal of material from any area required to be reexcavated
- Excavation and backfill of temporary drainage ditches

B. Extra Depth Excavation

The following extra depth excavations are not measured for payment:

1. Extra depth excavation because of Contractor negligence
2. Extra depth excavation (required by the Engineer) below the original Plan elevation of the bottom of the footing or the flow line of a culvert pipe that does not exceed 3ft (1 m)

If the Engineer relocates the structure or orders the elevation of the bottom of the footing or the flow line of the pipe to be lowered or undercut more than 3ft (1 m), the Contractor will be compensated for the extra depth excavated below the 3ft (1 m) limit according to Subsection 104.04 and Subsection 109.05.

Calculate the width of extra depth excavation using the diameter of the pipe or the width of the footing plus 2 ft (600 mm).

The length of extra depth excavation is equal to the length of that portion of the structure that is lowered more than 3 ft (1 m) below Plan elevation.

C. Backfill Materials Types I, II, III, and Graded Aggregate Materials

1. Types I and II

These materials (in place and accepted) are measured in cubic yards (meters) compacted.

Lateral measurements are confined to an area bounded by vertical planes lying not more than 1 ft (300 mm) outside of and parallel to the limits of the structure.

Length and depth measurements are confined to the dimensions of compacted material in place as specified by the Engineer. Materials placed outside the above limitations are not measured for payment.

2. Type III

The Department measures Type III material (complete, in place, and accepted) in cubic yards (meters).

Lateral measurements of Type III material are confined to an area bounded by vertical planes lying directly above the outside walls of the structure.

Longitudinal measurements are confined to the length of treatment installed as specified. Measurements of depth are the dimensions shown on the Plans or as directed.

3. Graded Aggregate Materials for Use with Thermoplastic Pipe

These materials (in place and accepted) are not measured separately for payment.

Standard 1030P specifies the minimum cubic feet of graded aggregate required per linear foot of installation for thermoplastic pipe diameters. This value shall be multiplied by the length of the pipe installation to determine the theoretical amount of graded aggregate, in cubic feet, necessary to construct a proper structural envelope around the pipe placed.

The theoretical total obtained above shall then be multiplied by the following formula:

- The dry density, in pounds per cubic foot, of graded aggregate material multiplied by .000475
Use QPL-2 to determine the dry density applicable to the source of the material.

The above computations shall serve to quantify a minimum tonnage of graded aggregate material associated with thermoplastic pipe installations that require QPL approved source documentation.

Width and depth excavations for thermoplastic pipe installation exceeding the dimensions provided on Standard 1030P by more than ten percent shall be multiplied by the pipe installation length and the above bulleted formula to compute additional required tonnage.

D. Normal Backfill

This Item is not measured separately, but is included in the measurement of the Items of excavation from which normal backfill materials are obtained.

207.4.01 Limits

General Provisions 101 through 150.

207.5 Payment

A. Excavation for Minor Structures

This Item will not be paid for separately except as provided in Subsection 207.4.B.

B. Sheet piling and Bracing

Sheet piling and bracing will not be paid for separately unless these materials are left in place at the written direction of the Engineer. In this case, the Contractor will be paid at invoice cost plus 10 percent.

C. Backfill Materials

Backfill material Type I, (measured as shown in Subsection 207.4.C.1) will be paid for according to Section 205 or Section 206.

The Department will pay for Types II and III separately at the Contract Unit Price per cubic yard (meter). This payment is full compensation for furnishing the materials from sources inside or outside the right-of-way, loading, unloading, hauling, handling, placing, and compacting the material.

D. Normal Backfill

This Item will not be paid for directly but will be paid at the Unit Price for the applicable excavation item from which the normal backfill materials are obtained.

E. Graded Aggregate Material

This Item will not be paid for separately.

Payment will be made under:

Item No. 207	Foundation backfill material, type II	Per cubic yard (meter)
Item No. 207	Imperfect trench backfill material, type III	Per cubic yard (meter)

207.5.01 Adjustments

General Provisions 101 through 150.

Section 208—Embankments

Delete Section 208 and substitute the following:

208.1 General Description

This work includes placing embankments, backfilling structures, and constructing earth berms and surcharges with suitable material excavated under Section 204, Section 205, Section 206, and Section 207.

Complete the work according to the lines, grades, and typical cross- sections shown on the Plans or established by the Engineer.

The work also includes preparing areas by backfilling stump holes and correcting surface irregularities where the embankment is to be constructed. This includes forming, compacting, and maintaining the embankment and placing and compacting approved material where unsuitable material has been removed.

Payment for this work is included in other appropriate Pay Items unless a specific Pay Item is set up in the Contract.

Apply all provisions of Section 161 to the work in this Section.

Perform Shoulder Construction according to Section 216.

208.1.01 Definitions

General Provisions 101 through 150.

208.1.02 Related References

A. Standard Specifications

- Section 161—Control of Soil Erosion and Sedimentation
- Section 201—Clearing and Grubbing Right-of-Way
- Section 204—Channel Excavation
- Section 205—Roadway Excavation
- Section 206—Borrow Excavation
- Section 207—Excavation and Backfill for Minor Structures
- Section 209—Subgrade Construction
- Section 216—Unpaved Shoulders
- Section 810—Roadway Materials
- Section 811—Rock Embankment
- Section 813—Pond Sand

B. Referenced Documents

- GDT 7
- GDT 20
- GDT 21

GDT 24a

GDT 24b

GDT 59

GDT 67

208.1.03 Submittals

General Provisions 101 through 150.

208.2 Materials

Embankment material classes are defined in Section 810, Section 811, and Section 813. The material incorporated into the roadway will be subject to the following limitations:

A. Embankment Material

Use embankment material classified as Class I, II, III, V, or VI except as noted below:

1. Inundated Embankments

A Special Provision in the Proposal will contain required gradation and other characteristics of materials for constructing embankments through reservoirs.

2. Intermittently Inundated Embankments

Build intermittently inundated embankments using any material suitable for embankment.

3. Embankments at Structures

Use Class I or II embankment materials within 10 ft (3 m) of any bridge structure. Class IIIC1 material may be used in Districts 1, 6, and 7. Class IIIC2 or IIIC3 material may only be used in Districts 1, 6, and 7 if approved by the Office of Materials and Testing, Geotechnical Environmental Pavement Bureau. Ensure that materials do not contain rock larger than 3 in (75 mm) for any dimensions.

B. Rock Embankment

Ensure that rock embankment placed as indicated on the Plans meets the requirements of Section 811 unless specified otherwise in the Plans or in the Special Provisions.

C. In-Place Embankment

Construct in-place embankment with Class I, II, III, V, or VI material.

D. Backfill Material

Use Class I or Class II backfill material furnished and stockpiled as defined in Subsection 810.2.01.A. Class IIIC1 material may be used in Districts 1, 6, and 7. Class IIIC2 or IIIC3 material may only be used in Districts 1, 6, and 7 if approved by the Office of Materials and Testing, Geotechnical Environmental Pavement Bureau.

E. Pond Sand Embankment

Use pond sand that meets the requirements of Section 813 as embankment material. Material is subject to the following approval limitations:

1. Pond sand will be approved on a stockpile basis only.
2. Pond Sand will not be approved for Type I or normal backfill materials or for backfill for mechanically stabilized walls.
3. Pond sand shall be encapsulated, when used as fill, with 2 ft (600 mm) of soil on the slopes and 3 ft (1 m) of soil on top.
4. Pond sand shall not be used on sidehill fills or fill widenings where any of the following conditions exist:

- a. The proposed fill slope is steeper than 2:1.
- b. The thickness of the proposed fill at its thinnest point, as measured perpendicularly from the new fill line to the existing ground slope/fill slope, is less than 7 ft (2.1 m), including 2 ft (600 mm) of soil cover.
- c. The fill height exceeds 30 ft (9 m).

208.2.01 Delivery, Storage, and Handling

General Provisions 101 through 150.

208.3 Construction Requirements

208.3.01 Personnel

General Provisions 101 through 150.

208.3.02 Equipment

General Provisions 101 through 150.

208.3.03 Preparation

General Provisions 101 through 150.

208.3.04 Fabrication

General Provisions 101 through 150.

208.3.05 Construction

A. Benching Excavation for Embankment

This work includes excavating material forming benches in the existing ground beneath proposed embankments. Form benches to increase the bond between the existing ground and the proposed embankment.

This work is required where embankments are placed on hillsides or against existing embankments, which will be indicated on the Plans.

Construct the benches approximately 12 ft (3.7 m) wide unless otherwise shown on the Plans. Use material removed in the excavation in the embankments. The Department will make no additional payment for this work.

B. Embankments

Follow these requirements when constructing embankments:

1. Preparation for Embankments

Before starting embankment construction, clear and grub the embankment area according to Section 201 and install Drainage Structures according to Section 550.

a. Depressions and Undercut Areas

Fill depressions below the ground surface and undercut areas with suitable material. Remove unsuitable or unstable material and compact according to Subsection 208.3.05.B.1.c before beginning embankment construction.

b. Scarification and Other Preparation

Plow and scarify the entire area upon which the embankment is to be placed (except inundated areas) at least 6 in (150 mm) deep.

Before placing the embankment, recompact loosened soil to the approximate density of the underlying soil. Cut benches as specified in Subsection 208.3.05.A.

c. Compaction Under Shallow Fills

When the depth of fill and surfacing is 3 ft (1 m) or less, compact the original ground compact at least 1 ft (300 mm) deep to at least 95 percent of the maximum laboratory dry density as determined from representative samples of the compacted material using, GDT 7, GDT 24a, GDT 24b, or GDT 67 whichever applies.

The in-place density of the compacted fill will be determined according to GDT 20, GDT 21, or GDT 59, whichever applies.

d. Embankments Over Existing Roads, Parking Areas, and Floors

Thoroughly plow or scarify all portions of existing unpaved roads and flexible pavements. Destroy cleavage planes before placing the embankment.

- 1) Remove the old pavement with rigid surfaces if the new embankment is not more than 3 ft (1 m) high.
- 2) Break remaining rigid pavements that are within 10 ft (3 m) of the finished grade so that no section larger than 10 ft² (1 m²) remains intact.

2. Embankment Formation

Use the following requirements when constructing the embankment formation:

a. Layer Construction

Except as noted in Subsection 208.3.05.B.2.d, construct the embankments in parallel layers. Deposit the material and spread in horizontal layers not more than 8 in (200 mm) thick, loose measurement, for the full width of the cross-section. Use motor graders, bulldozers, or other approved equipment to keep layers uniform. Compact the layers using a sheepsfoot roller. The Engineer may permit the use of vibratory rollers whenever the embankment soils consist of Class IA1, IA2, or IA3 materials.

b. Moisture Content

Compact each layer within the range of optimum moisture content to achieve the compaction specified below.

Do not construct successive layers on previous layers that exhibit excessive pumping under construction equipment regardless of compaction.

Dry material if it contains too much moisture. Ensure the moisture content is sufficient for stability and compaction.

Add water if the material is too dry and uniformly mix it with the soil for stability and compaction. The Department will not measure water added to the material under this requirement for payment. It is considered incidental to the satisfactory completion of the work.

c. Degree of Compaction

Compact the embankment at bridge structures to at least 100 percent of the maximum laboratory dry density. Compact for the full depth of the embankment, beginning at the toe of the slope and extending 100 ft (30 m) from the end of the bridge.

Compact embankment other than at bridge structures to at least 95 percent of the maximum laboratory dry density to within 1 ft (300 mm) of the top of the embankment. Compact the top 1 ft (300 mm) of the embankment to at least 100 percent of the maximum laboratory dry density.

If grading and paving are let in separate contracts, the paving Contractor shall recompact the top 6 in (150 mm) to at least 100 percent of the maximum laboratory density.

The maximum laboratory dry density will be determined from representative samples of the compacted material using GDT 7, GDT 24a, GDT 24b, or GDT 67, whichever applies. The in-place density of the compacted fill will be determined according to GDT 20, GDT 21, or GDT 59, whichever is applicable.

d. Special Conditions

Follow these special requirements:

- 1) Build layers as parallel as possible. In certain cases the Engineer may permit steeper slopes at ends of the embankments.

- 2) In swamp or inundated areas that will not support the equipment, build the lower part of the fill by dumping successive loads in layers no thicker than necessary to support the hauling equipment.
- 3) Build and compact the remainder of fills in layers as specified above.

e. Embankments at Structures

Use Class I or II material when constructing embankments over and around pipes, culverts, arches, and bridges according to Subsection 810.2.01.A.1. Class IIIC1 material may be used in Districts 1, 6, and 7.

- 1) Compact the material as specified in Subsection 208.3.05.B.2.c.
- 2) Place the specified material on both sides of bridge structures for a distance of at least 10 ft (3 m).

NOTE: Do not place rock larger than 4 in (100 mm) diameter within 2 ft (600 mm) of any drainage structure.

Before any traffic is allowed over any structure, provide a sufficient depth of material over and around the structure to protect it from damage or displacement.

f. Method of Handling Classes of Soils

Handle the different classes of soils using the following methods:

1) Class IIB3 and Better Soils

Distribute and compact these soils in 8 in (200 mm) uniform layers over the entire width of the embankment. Use these soils (when available in sufficient quantities) in the top 1 ft (300 mm) of the roadbed. Reserve these soils for this purpose when directed by the Engineer

2) Class IIB4 Soils

Distribute and compact these soils in 8 in (200 mm) layers over the entire width of the embankment. Class IIB4 soils may be used in the top 12 inch (300 mm) of subgrade in Districts 1, 6, and 7. Class IIB4 soils may be used in the top 12 inch (300 mm) of subgrade in Districts 2, 3, 4, and 5 with a stabilizing agent if approved by the Office of Materials and Testing, Geotechnical Environmental Pavement Bureau. If Class IIB3 or better soils are available in borrow pits, use these soils in the top 12 inch (300 mm) of subgrade.

3) Class IIIC1 Soils

Class IIIC1 soils excavated per Section 204, 205 or 207, which excludes Section 206 (Borrow), may be used in Districts 1, 6, and 7 in embankments and within the top 12 inch (300 mm) of subgrade if approved by the Office of Materials and Testing, Geotechnical Environmental Pavement Bureau. If Class IIB4 or better soils are available in borrow pits, use these soils in the top 12 inch (300 mm) of subgrade. used for subgrade.

4) Class IIIC2 and IIIC3 Soils

Class IIIC2 and IIIC3 soils excavated per Section 204, 205 or 207, which excludes Section 206 (Borrow) may be used in Districts 1, 6, and 7 in embankments, except within 5 feet (1.5 m) of the bottom of subgrade directly beneath the pavement, if approved by the Office of Materials and Testing, Geotechnical Environmental Pavement Bureau.

5) Class IIIC4 Soils

Class IIIC4 chert clay soils in District 6 with less than 55 percent passing the No. 10 (2 mm) sieve may be used in embankments and subgrade. All other Class IIIC4 soils may not be used.

6) Class IV Soils

Do not use these soils in embankments. Waste these soils or (when designated in the Plans or directed by the Engineer) stockpile them and use them for blanketing fill slopes.

7) Class V Soils

Place these soils in the same manner as Class IIB4 soils. Pulverize large particles to obtain the proper compaction.

8) Class VI Rock

Place rock in uniform layers not over 3 ft (1 m) thick and distribute it over the embankments to avoid pockets. Fill voids with finer material.

Do not place rock larger than 6 in (150 mm) in diameter within 3 ft (1 m) of the finished surface of the embankment.

Do not place rock larger than 6 in (150 mm) in diameter within 2 ft (600 mm) of the outer limits of proposed posts or utility poles.

Do not place rock at bridge end bents within 10 ft (3 m) of pile locations.

9) All Classes

Place mixtures of the above classes together with random material such as rock, gravel, sand, cinders, slag, and broken-up pavement so that coarse particles are dumped near the outer slopes and finer particles near the center of the roadway.

Produce a gradual transition from the center to the outside. If material is too large to place in 8 in (200 mm) layers, treat it as rock or break it down and place it in 8 in (200 mm) layers.

3. Embankment Consolidation at Bridge Ends

When consolidating embankments at bridge ends, use the following specifications:

- a. When a waiting period is required in the Plans or by Special Provision, place end fills at bridges in time for consolidation readings to indicate that both the fill and the natural ground have reached the desired degree of stability.
- b. Delay constructing bridge portions during the period of consolidation as shown on the Plans or as required by a Special Provision.

The Plans or the Special Provisions will indicate the estimated time required to reach consolidation.

The Engineer may extend or shorten this waiting period based on settlement readings taken on points placed in the fills. The longer or shorter waiting period will not constitute a valid claim for additional compensation.

Follow these specifications when extending a waiting period:

- 1) Extending an estimated waiting period may lead to increasing the Contract time. If the Contract is on a calendar day or completion date basis, the Department may increase the calendar days equal to the maximum number of calendar days involved in the extension.
 - 2) When a time extension causes additional delay due to seasonal changes, the Engineer may recompute the time extension on an available day basis.

When the Contract is on an available day basis, the time increase will be equal to the greatest number of available days involved in the extension.
 - 3) When time charges on separate Bridge Contracts are controlled by Special Provisions that set forth the availability of bridge sites, extending an estimated waiting period controls the availability of that bridge site only; time charges will be adjusted according to the Special Provision.
- c. Construct the embankment at bridge ends full-depth to the subgrade template (except for the stage construction providing a bench for the end bent) unless otherwise stated in the Plans and compact thoroughly before driving a piling at bridge ends.

The minimum acceptable length of completed full-depth embankment is equal to the maximum width of fill between slope stakes at the end of the bridge. The Department will measure the minimum length of full-depth embankment along the roadway centerline away from the end-of-bridge Station.

C. In-Place Embankment

Construct embankments designated on the Plans and in the Proposal as “In-Place Embankment” using either a hydraulic or conventional dry land construction method and using materials obtained from within the construction limits of the Right-of -Way or from borrow pits, whichever is appropriate.

Regardless of the method of construction, the Department will measure the entire embankment for payment as in-place embankment.

1. Construction

- Build embankments according to this Section when hydraulic or conventional dry land construction methods are used.
- Furnish equipment suitable for the method chosen to complete the work. Equipment is subject to the Engineer’s approval.
- When using a hydraulic method is used, conform to these additional requirements:
 - a. Using baffles for construction is permitted as long as the embankment slopes are not steeper than indicated on the Plans.
 - b. Use of excess material placed outside the prescribed slopes to raise the fill is permitted.
 - c. Leave openings in the embankments at the bridge site as indicated on the Plans.
Dredge material that invades the openings or existing channels at no additional expense to the Department. Provide the same depth of channel at mean low water as existed before the construction of the embankment.
 - d. Do not excavate or dredge material within 500 ft (150 m) of the toe of the embankment or existing structures, unless otherwise shown on the Plans.
 - e. Place in-place embankment in areas previously excavated below the ground line in a uniform mass beginning at one end of the excavated area and continuing to the other end of the operation. Avoid forming of muck cores in the embankment.
 - f. Construct the embankment at the farthest points along the roadway from the bridge ends and progress to the end of the excavation area beyond the toe of the slope of endrolls at bridge ends.
 - g. Remove timber used for temporary bulkheads or baffles from the embankment.
 - h. Fill and thoroughly compact the holes.

2. Maintenance

- a. Maintain the embankment at grade until it has been completed and accepted. Assume responsibility for slides, washouts, settlement, subsidence, or mishaps to the work while under construction.
- b. Keep constructed embankment stable and replace displaced portions before Final Acceptance of the entire Contract.
- c. Remove and dispose of excess materials, including fill, detours, and erosion deposits placed outside the prescribed slopes in wetland areas.

3. Permits

Obtain (at no additional expense to the Department) necessary permits or licenses from the appropriate authorities to operate dredges and other floating equipment in waters under their jurisdiction, unless otherwise provided for in the Contract.

4. Erosion Control

In addition to the provisions of Section 161, follow additional erosion, siltation, and pollution control measures specified in the Plans or Special Provisions.

D. Rock Embankment

This work includes furnishing materials either from the roadway excavation or other sources and hauling and the placing of rock embankment. Use materials that meet the requirements of Subsection 208.2.B, as shown on the Plans or directed by the Engineer.

1. Place the rock in uniform layers not over 3 ft (1 m) thick. Distribute rock over the embankment to avoid pockets.
2. Fill voids with rock fines. Do not use rock larger than 6 in (150 mm) for any diameter within 3 ft (1 m) of the finished grade of the embankment, or within 2 ft (600 mm) of any structure.
3. Do not place rock at bridge end bents within 10 ft (3 m) of pile locations. Construct rock embankment and adjoining earth embankment concurrently. Ensure that neither is larger than 4 ft (1.2 m) higher than the other at any time.

E. Final Finishing

After constructing the entire embankment, shape the surface of the roadbed and the slopes to reasonably true grade and cross-sections as shown on the Plans or established by the Engineer.

Open ditches, channels, and drainage structures (both existing and those constructed or extended) to effectively drain the roadway. Maintain the embankment areas until Final Acceptance of the Project.

208.3.06 Quality Acceptance

General Provisions 101 through 150.

208.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

208.4 Measurement

The following section details measurement for payment for the work described in this Section:

- A. Except as provided herein, there will be no measurement for payment for the work covered by this Section.
- B. The Department will compute the quantity of in-place embankment or rock embankment using the average end area method, or other acceptable methods, when embankment is in place and accepted.

The quantity will be calculated as the neat volume, above the original ground surface, between the template line shown on the Plans or authorized changes by the Engineer, and the original ground surface.

The original ground surface is determined by conventional field, photogrammetric, or other methods. The Department will not deduct for the volume of culverts and manholes.

In-place embankment necessary for the construction of temporary detours will not be measured for payment and is considered incidental to the completion of the work unless specifically stated otherwise on the Plans.

Where work includes excavating of unstable materials below the ground line, the volume of embankment required for backfill below the ground line is calculated based on the neat line measurement for the cross-section shown on the Plans or established by the Engineer by the average end area method or other acceptable methods.

Where permitted by the Engineer or required by the Plans, material removed from the existing roadbed, special ditches, berm ditches, or dry land borrow pits and used in making embankment will be paid for as in-place embankment regardless of the method of excavation.

208.4.01 Limits

General Provisions 101 through 150.

208.5 Payment

Except as provided for herein, the Department will not make separate payment for placing embankments, backfilling structures, and constructing earth berms, including surcharges.

Payment will be included at the Contract Unit Price for the items covered by Section 204, Section 205, and Section 206. Prices are full compensation for The Work covered by this Section.

The Unit Prices bid per cubic yard (meter) for in-place and rock embankments (when included as Contract bid Items) are full compensation for furnishing suitable material, hauling, placing, compacting, finishing, and dressing according to these Specifications or as directed by the Engineer.

Payment will be made under:

Item No. 208	In-place embankment	Per cubic yard (meter)
Item No. 208	Rock embankment	Per cubic yard (meter)

208.5.01 Adjustments

General Provisions 101 through 150.

Section 209—Subgrade Construction

Delete Section 209 and Substitute the following:

209.1 General Description

This work includes placing, mixing, compacting, and shaping the top 6 in (150 mm) or the Plan-indicated thickness of the roadbed in both excavation and embankment areas.

This work also includes subgrade stabilization, select material subgrade, and shoulder stabilization.

209.1.01 Definitions

General Provisions 101 through 150.

209.1.02 Related References

A. Standard Specifications

Section 109—Measurement and Payment

Section 412—Bituminous Prime

Section 803—Stabilizer Aggregate

Section 810—Roadway Materials

Section 815—Graded Aggregate

B. Referenced Documents

GDT 7

GDT 20

GDT 21

GDT 24a

GDT 24b

GDT 59

GDT 67

209.1.03 Submittals

General Provisions 101 through 150.

209.2 Materials

A. Subgrade Materials

If the Plans do not show the source of material for subgrade, the Engineer will direct the Contractor according to the Specifications, or implement a Supplemental Agreement to ensure a satisfactory subgrade.

If the existing roadway excavation or borrow materials are not suitable or available for stabilizing the subgrade, use the quantity of stabilizer materials defined below in Subsection 209.2.B.

B. Subgrade Stabilizer Materials

Material	Section
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Material	Section
Type I Stabilizer Aggregate	803.2.01
Type II Stabilizer Aggregate	803.2.02
Class IIB3 or Better Soil	810.2.01.A.1
Type III Stabilizer Aggregate	803.2.03
Type IV Stabilizer Sand	803.2.04

C. Select Material Subgrade

Material	Section
Class IIB3 or Better Soil in Districts 2, 3, 4, and 5	810.2.01.A.1
Class IIB4 or Better Soil in Districts 1, 6, and 7	810.2.01.A.1
Class IIIC4, chert clay soils in District 6 with less than 55% passing the No. 10 (2 mm) sieve	810.2.01.A.1
Graded Aggregate	815

D. Shoulder Stabilization

Material	Section
Shoulder Stabilization	803.2.02, Type II

209.2.01 Delivery, Storage, and Handling

General Provisions 101 through 150.

209.3 Construction Requirements

209.3.01 Personnel

General Provisions 101 through 150.

209.3.02 Equipment

General Provisions 101 through 150.

209.3.03 Preparation

General Provisions 101 through 150.

209.3.04 Fabrication

General Provisions 101 through 150.

209.3.05 Construction

A. Subgrade Construction

Construct subgrade as follows:

1. Plow, harrow, and mix the entire surface of the in-place subgrade to a depth of at least 6 in (150 mm).
2. After thoroughly mixing the material, bring the subgrade to Plan line and grade and compact it to 100 percent of the maximum laboratory dry density.
3. If the subgrade needs to be stabilized, or if a subsequent contract provides for base construction, do not apply density requirement at this stage.

If a subsequent Contract provides for base construction, eliminate mixing and compact the in-place subgrade to 95 percent of the laboratory maximum dry density.

4. Ensure that the subgrade can firmly support construction equipment before placing subsequent layers of base and paving materials. The subgrade must support construction equipment without excessive movement regardless of compaction.
5. Rework unstable areas of subgrade to a moisture content that will provide stability and compaction. The Engineer may direct the Contractor to proof roll the subgrade with a loaded dump truck.
6. Compact the subgrade using a sheepfoot roller.
The Engineer may permit the use of vibratory rollers whenever the subgrade soils consist of Class IA1, IA2, or IA3 materials.
7. Ensure that subgrade material used underneath soil-cement base meets the requirements of Subsection 301.3.03.A.

B. Subgrade Stabilization

Construct a stabilized subgrade according to Plans or as directed:

1. Undercut and dispose of the amount of subgrade material that will be displaced with the aggregate or selected material according to the Engineer's direction.
2. Leave material off the subgrade in fill sections requiring stabilization.
3. Place the amount of material specified in Subsection 209.2.B. on the subgrade as specified on the Plans or established by the Engineer.
4. Thoroughly incorporate the material into the existing subgrade to a depth of 6 in (150 mm), or as indicated on the Plans. Plow, disk, harrow, blade, and then mix with rotary tillers until the mixture is uniform and homogeneous throughout the depth to be stabilized.
5. Finish the stabilized subgrade to the Plan line, grade, and cross-section. Compact it to 100 percent of the maximum laboratory dry density as defined in Subsection 209.3.06.
Plant mixing is permitted as an alternative to the mixed-in-place method.
6. Eliminate the mixing and scarifying method before compaction in undercut areas where Type III Stabilizer Aggregates are specified, unless otherwise specified by the Engineer.

C. Select Materials Subgrade

Place select materials as follows:

1. Place the subgrade with a uniform blanket of select material consisting of Class I or II soil or graded aggregate (according to Plan dimensions or as directed by the Engineer). Class IIIC1 soils may be used in Districts 1, 6, and 7 within the top 12 inch (300 mm) of subgrade if approved by the Office of Materials and Testing, Geotechnical Environmental Pavement Bureau. Do not use Class IIIC2, IIIC3, or IIIC4 soils within the top 12" (300 mm) of subgrade unless a stabilizing agent approved by the Engineer is added, or if approved by the Office of Materials and Testing, Geotechnical Environmental Pavement Bureau. Class IIIC4, chert clay soils in District 6 with less than 55 percent passing the No. 10 (2 mm) sieve may be used for subgrade.
2. Use the select material reserved from the grading or borrow operations. If material is not available through this source, obtain it from other sources.
3. Finish and compact the material according to Subsection 209.3.05.A.

D. Shoulder Stabilization

Stabilize the shoulder as follows:

1. Spread the stabilizer aggregate at the rate and to the dimensions indicated on the Plans.
2. Mix the aggregate with the in-place shoulder material thoroughly to the Plan depth.
3. Compact the area thoroughly and finish it to Plan dimensions.
4. Prime the stabilized area according to Section 412 when a paving course is required on the shoulders.

E. Finishing Subgrade

When finishing subgrade use the following procedure:

1. Leave the underlying subgrade in cuts and fills low enough to accommodate the additional material when the work requires either subgrade stabilization, select material subgrade, or stabilization for shoulders.
2. Test short sections in curb and gutter areas might be necessary to obtain the proper elevation.
3. Blade the surface of the completed subgrade to a smooth and uniform texture.

209.3.06 Quality Acceptance

The Department will test representative samples of compacted material to determine the laboratory maximum dry density using GDT 7, GDT 24a, or GDT 67 as applicable.

The Department will determine in-place density of the compacted subgrade according to GDT 20, GDT 21, or GDT 59, as applicable.

Ensure that the centerline profile conforms to the established elevations with an acceptable tolerance of ± 0.5 in (± 13 mm). The acceptable tolerance under a template conforming to the designated cross section shall be ± 0.25 in (± 6 mm).

Have the Department test the maximum dry density using methods according to Subsection 209.3.05.A. When base construction is not in the same Contract, the tolerances may be 1 in (25 mm), 0.5 in (13 mm), and 95 percent respectively.

209.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

209.4 Measurement

A. Subgrade Construction and Finishing Subgrade

The Department will make no separate measurement or payment for the work described in this Section.

B. Subgrade Stabilization

Subgrade stabilization materials, as defined in Subsection 209.3.05.B is measured by the ton (megagram), cubic yard (meter), or square yard (meter) of the specified thickness if none of the existing Roadway Excavation and/or Borrow Materials are suitable and available for stabilizing the subgrade.

C. Select Material Subgrade

Select materials, conforming to Subsection 209.3.05.C are measured by the cubic yard (meter) in the hauling vehicle, per ton (megagram) according to Subsection 109.01, or by the square yard (meter) of the specified thickness when roadway excavation and/or borrow materials are not available or suitable for this Item.

D. Shoulder Stabilization

Shoulder stabilization is measured by the cubic yard (meter) or ton (megagram) as specified in Subsection 209.4.B.

209.4.01 Limits

General Provisions 101 through 150.

209.5 Payment

A. Subgrade Construction

The Department will make no separate payment for subgrade construction or for finishing subgrade.

B. Subgrade Stabilization

Subgrade stabilization complete and accepted according to Subsection 209.3.05.B will be paid for at the Contract Unit Price per cubic yard (meter), per ton (megagram), or per square yard (meter). This price is full compensation for furnishing the materials, hauling, placing, mixing, compacting, and finishing the stabilized subgrade.

C. Select Material Subgrade

Select material complete, accepted, and measured according to Subsection 209.4.C will be paid for at the Contract Unit Price per cubic yard (meter), per ton (megagram), or per square yard (meter). This price is full compensation for furnishing the material where required, hauling, placing, mixing, compacting and finishing the select material subgrade.

D. Shoulder Stabilization

This Item will be measured by Subsection 209.4.B. and paid for according to Subsection 209.5.B. This Item also includes furnishing and applying bituminous prime.

Payment will be made under:

Item No. 209	Stabilizer materials (class), (type), (thickness)	Per ton (megagram), cubic yard (meter), or square yard (meter)
Item No. 209	Select material subgrade (class), (type), (thickness)	Per ton (megagram), cubic yard (meter), or square yard (meter)
Item No. 209	Stabilizer aggregate for shoulders	Per ton (megagram), or cubic yard (meter)

209.5.01 Adjustments

General Provisions 101 through 150.

Section 310—Graded Aggregate Construction

Delete Section 310 and substitute the following:

310.1 General Description

This work includes constructing a base, subbase or shoulder course composed of mineral aggregates. Construct according to these Specifications and to the lines, grades, thickness, and typical cross-sections shown on the Plans or established by the Engineer.

The provisions of Section 300 apply to this work.

310.1.01 Definitions

General Provisions 101 through 150.

310.1.02 Related References

A. Standard Specifications

Section 105—Control of Work

Section 300—General Specifications for Base and Subbase Courses

Section 412—Bituminous Prime

Section 815—Graded Aggregate

Section 821—Cutback Asphalt

Section 823—Cutback Asphalt Emulsion

B. Referenced Documents

AASHTO T 180

GDT 21

GDT 59

310.1.03 Submittals

General Provisions 101 through 150.

310.2 Materials

Ensure that materials meet the requirements of the following Specifications:

Material	Section
Graded aggregate	815
Cutback asphalt, RC-30, RC-70, RC-250 or MC-30, MC-70, MC-250	821.2.01
Cutback Asphalt Emulsion, CBAE-2	823.2.01
Blotter material (sand)	412.3.05.G.3

310.2.01 Delivery, Storage, and Handling

General Provisions 101 through 150.

310.3 Construction Requirements

310.3.01 Personnel

General Provisions 101 through 150.

310.3.02 Equipment

Provide equipment in satisfactory condition for proper construction of the base, subbase or shoulder course. Use any applicable equipment specified in Subsection 412.3.02, "Equipment" for Bituminous Prime.

310.3.03 Preparation

Prepare the subgrade or subbase as specified in Subsection 300.3.03.C, "Preparing the Subgrade" or Subsection 300.3.03.D, "Preparing the Subbase." Place graded aggregate materials only on dry, thawed subgrade or subbase.

310.3.04 Fabrication

General Provisions 101 through 150.

310.3.05 Construction

A. Placing Material

Use the central plant mix method unless producing aggregates (from an approved source or deposit) that conform to the requirements of Section 815.

Use the following steps to mix base and spread subbase or shoulder course.

1. Mixing

When blending two sizes of aggregate, proportion the aggregate and water, if needed, into the central plant. Mix until producing a homogeneous and uniform mixture.

2. Spreading

To obtain the specified thickness, uniformly spread materials to the proper depth with a mixture spreader. Do not use materials containing frost or frozen particles.

a. One-Course Construction

Lay one course to a maximum thickness of 8 in (200 mm) compacted.

b. Multiple-Course Construction

If the thickness of the base, subbase or shoulder course exceeds 8 in (200 mm), construct it in 2 or more courses of equal thickness.

B. Compacting Material

Use the following steps to compact and finish a base, subbase, or shoulder course.

1. Moisture Content

Ensure that the moisture content of materials is uniformly distributed and allows compaction to the specified density.

Unless approved by the Office of Materials and Research, no graded aggregate will be shipped to a project when the moisture content of the material exceeds two percent of optimum moisture.

2. Compaction

After shaping the spread material to line, grade, and cross-section, roll to uniformly compact the course. If using Group 1 aggregate, roll to at least 98 percent of maximum dry density. If using Group 2 aggregate, roll to at least 100 percent of the maximum dry density.

If using graded aggregate mixtures composed of either group as base for paved shoulders 6 ft (1.8 m) wide or less, compact to at least 96 percent of the maximum dry density.

Regardless of compaction, ensure that the compacted base is sufficiently stable to support construction equipment without pumping. If the base material is unstable from too much moisture, dry and rework the base material. Dry and rework the underlying subgrade, if necessary.

a. One-Course Construction

- 1) After compaction, shape to the required grade, line, and cross-section.
- 2) Add water as necessary to develop the proper moisture content.
- 3) Roll until the surface is smooth, closely knit, and free of cracks.
- 4) Correct all defects according to Subsection 300.3.06.B, "Repairing Defects."

b. Multiple-Course Construction

- 1) After compacting the first course, shape the surface again to line, grade, and cross section.
- 2) Add water as necessary to develop the proper moisture content.
- 3) Spread and compact the second and any succeeding courses without rolling the first course again.
- 4) Finish the surface according to the procedure specified for one-course construction.

c. Irregular Areas

In places inaccessible to the roller, obtain the required compaction with mechanical tampers approved by the Engineer. Apply the same density requirements as stated above in Subsection 310.3.05.B.

C. Finishing

Finish the surface of the subbase for Portland cement concrete pavement or the base of asphaltic concrete pavement with automatically controlled screed equipment when required by Subsection 300.3.02.H, "Fine Grading Machine" of the Specifications. Furnish, install, and maintain the sensing wires needed to control the finish operation as a part of the Pay Item. When automatically controlled screed equipment is not required, fine grading with motor graders is permitted.

Finish immediately after the placing and compacting operations. After finishing, compact the subbase again, according to Subsection 310.3.05.B, "Compacting Material."

D. Protecting the Base, Subbase or Shoulders

Maintain the course until the Engineer determines that it has cured sufficiently and is ready to prime. Maintain by additional wetting, rolling, and blading as necessary. Repair any defects according to Subsection 300.3.06.B, "Repairing Defects."

These protection measures do not relieve the Contractor of maintaining the Work until final acceptance as specified in Section 105.

E. Priming the Base

Apply bituminous prime according to Section 412 unless using:

- Graded aggregate base under Portland cement concrete pavement
- Graded aggregate base under asphaltic concrete 5 in (125 mm) or more in total thickness

310.3.06 Quality Acceptance

A. Compaction Tests

1. Determine the maximum dry density from representative samples of compacted material, according to AASHTO T180, Method D.
2. Determine the in-place density of finished courses according to GDT 21 or GDT 59, where applicable.

B. Finished Surface

Check the finished surface of the base, subbase, or shoulder course as follows:

1. Check the longitudinal surface using a 15 ft (4.5 m) straightedge parallel to the centerline.

2. Check the transverse surface by using one of the following tools:
 - A template, cut true to the required cross-section and set with a spirit level on non-superelevated sections
 - A system of ordinates, measured from a stringline
 - A surveyor's level
3. Ensure that ordinates measured from the bottom of the template, stringline, or straightedge, to the surface do not exceed 1/4 in (6 mm) at any point. Rod readings shall not deviate more than 0.02 ft (6 mm) from required readings.
4. Correct any variations from these requirements immediately according to Subsection 300.3.06.B, "Repairing Defects."

C. Thickness Tolerances

1. Thickness Measurements
 - a. Thickness requirements apply to shoulder construction where the Plans specify a uniform thickness, or where the shoulders will be surfaced.
 - b. Determine the thickness of the base, subbase, or shoulder course, by making as many checks as necessary to determine the average thickness.
2. Deficient Thickness
 - a. If any measurement is deficient in thickness more than 1/2 in (13 mm), make additional measurements to determine the deficient area.
 - b. Correct any area deficient between 1/2 in (13 mm) and 1 in (25 mm) to the design thickness by using one of the following methods according to these Specifications:
 - Add additional quantities of the same materials and reconstruct to the required thickness
 - Leave in place and accept payment for the materials and area at 1/2 the Contract Unit Price for the deficient area.
 - c. Correct any area deficient in thickness by more than 1 inch (25 mm) by adding additional quantities of the same material and reconstructing to the required thickness in accordance with these Specifications.
 - d. If payment is made by the ton (megagram), payment for additional material to correct deficiencies will be made at the Contract Unit Price with no additional cost to the Department for scarification, mixing or compaction.
 - e. If payment is made by the square yard (meter), no payment will be made for additional material required to correct deficiencies or for reconstructing deficient work.
3. Average Thickness
 - a. The average thickness per linear mile (kilometer) is determined from all measurements within the mile (kilometer) increments except the areas deficient by more than 1/2 in (13 mm) and not corrected.
 - b. The average thickness shall not exceed the specified thickness by more than 1/2 in (13 mm).
 - c. If the basis of payment is per ton (megagram), and the average thickness for any mile (kilometer) increment exceeds the allowable 1/2 in (13 mm) tolerance, the excess quantity in that increment will be deducted from the Contractor's payments.
 - d. The excess quantity is calculated by multiplying the average thickness that exceeds the allowable 1/2 in (13 mm) tolerance by the surface area of the base, subbase, or shoulder.
 - e. If the basis of payment is per square yard (meter), no deduction will be made for excess thickness.

310.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

310.4 Measurement

A. Graded Aggregate

Where specified for payment by the ton (megagram), graded aggregate base, subbase or shoulder materials are measured in tons (megagrams), mixed and accepted. When hauling material to the roadway, the actual weight of each loaded vehicle is determined with an approved motor truck scale.

Where specified for payment by the square yard (meter) for a certain thickness, the surface length is measured along the centerline, and the width is specified on the Plans. Measure irregular areas, such as turnouts and intersections, by the square yard (meter).

B. Bituminous Prime

Bituminous prime is not measured for separate payment.

310.4.01 Limits

General Provisions 101 through 150.

310.5 Payment

A. Graded Aggregate

Graded aggregate base, subbase, or shoulder course will be paid for at the Contract Unit Price per ton (megagram) or per square yard (meter), complete, in place, and accepted. This payment shall be full compensation for:

- Materials
- Shaping and compacting the existing roadbed
- Loading, hauling, and unloading
- Crushing and processing
- Mixing
- Spreading
- Watering
- Compacting and shaping
- Maintenance
- Priming, when required
- All incidentals necessary to complete The Work

B. Graded Aggregate with Recycled Concrete Aggregate

If used in lieu of graded aggregate, the pay tons for graded aggregate with Recycled Concrete Aggregate calculated in accordance with Subsection 310.4.C will be paid for at the graded aggregate contract unit price. This pay shall be full compensation for:

- Materials
- Shaping and compacting the existing roadbed
- Loading, hauling, and unloading
- Crushing and processing
- Mixing
- Spreading
- Watering
- Compacting and shaping
- Maintenance

- Priming, when required
- All incidentals necessary to complete The Work

Payment will be made under:

Item No. 310	Graded aggregate (base, subbase, shoulder course)—including material	Per ton (megagram) or square yard (meter)
Item No. 310	Graded aggregate with Recycled Concrete Aggregate (base, subbase, shoulder course)—including material	Per ton (megagram)
Item No. 310	Graded aggregate base and shoulder course— including material	Per ton (megagram) or square yard (meter)
Item No. 310	Graded aggregate base and shoulder course with Recycled Concrete Aggregate— including material	Per ton (megagram)

310.5.01 Adjustments

General Provisions 101 through 150.

Section 400—Hot Mix Asphaltic Concrete Construction

Delete Section 400 and substitute the following:

400.1 General Description

This work includes constructing one or more courses of bituminous plant mixture on the prepared foundation or existing roadway surface. Ensure the mixture conforms with lines, grades, thicknesses, and typical cross sections shown on the Plans or established by the Engineer.

This section includes the requirements for all bituminous plant mixtures regardless of the gradation of the aggregates, type and amount of bituminous material, or pavement use.

Acceptance of work is on a lot-to-lot basis according to the requirements of this Section and Section 106.

400.1.01 Definitions

Segregated Mixture: Mixture lacking homogeneity in HMA constituents of such magnitude there is a reasonable expectation of accelerated pavement distress or performance problems. May be quantified by measurable changes in temperature, gradation, asphalt content, air voids, or surface texture.

New Construction: A roadway section more than 0.5 mile (800 m) long that is not longitudinally adjacent to the existing roadway. If one or more lanes are added longitudinally adjacent to the existing lane, the lane(s) shall be tested under the criteria for a resurfacing project. If work is performed on the existing roadway including leveling, grade changes, widening and/or resurfacing then that lane shall be tested under the criteria for a resurfacing project.

Trench Widening: Widening no more than 4 ft. (1.2 m) in width.

Comparison Sample: Opposite quarters of material sampled by the Contractor.

Independent Sample (Quality Assurance Sample): A sample taken by the Department to verify an acceptance decision without regard to any other sample that may also have been taken to represent the material in question.

Referee Sample: A sample of the material retained during the quartering process which is used for evaluation if a comparison of Contractor and Departmental split sample test results is outside allowable tolerances.

400.1.02 Related References

A. Standard Specifications

Section 106—Control of Materials

Section 109—Measurement and Payment

Section 152—Field Laboratory Building

Section 413—Bituminous Tack Coat

Section 424—Bituminous Surface Treatment

Section 802—Coarse Aggregate for Asphaltic Concrete

Section 828—Hot Mix Asphaltic Concrete Mixtures

B. Referenced Documents

AASHTO T 315

AASHTO T 209

AASHTO T 202

AASHTO T 49

Department of Transportation Standard Operating Procedure (SOP) 15

Department of Transportation Standard Operating Procedure (SOP) 27

Department of Transportation Standard Operating Procedure (SOP) 40

GDT 38

GDT 73

GDT 78

GDT 83

GDT 119

GDT 125

GDT 126

GDT 134

GSP 15

GSP 21

QPL 1

QPL 2

QPL 7

QPL 26

QPL 30

QPL 39

QPL 41

QPL 45

QPL 65

QPL 67

QPL 70

QPL 77

400.1.03 Submittals

A. Invoices

Furnish formal written invoices from a supplier for all materials used in production of HMA when requested by the Department. Show the following on the Bill of Lading:

- Date shipped
- Quantity in tons (megagrams)
- Included with or without additives (for asphalt cement)

Purchase asphaltic cement directly from a supplier listed on Qualified Products List 7 and provide copies of Bill of Lading at the Department's request.

B. Paving Plan

Before starting asphaltic concrete construction, submit a written paving plan to the Engineer for approval. Include the following on the paving plan:

- Proposed starting date
- Location of plant(s)

- Rate of production
- Average haul distance(s)
- Number of haul trucks
- Paver speed feet (meter)/minute for each placement operation
- Mat width for each placement operation
- Number and type of rollers for each placement operation
- Sketch of the typical section showing the paving sequence for each placement operation
- Electronic controls used for each placement operation
- Temporary pavement marking plan

If staged construction is designated in the Plans or contract, provide a paving plan for each construction stage.

If segregation is detected, submit a written plan of measures and actions to prevent segregation. Work will not continue until the plan is submitted to and approved by the Department.

C. Job Mix Formula

Submit to the Engineer a written job mix formula proposed for each mixture type to be used based on an approved mix design. Furnish the following information for each mix:

- Specific project for which the mixture will be used
- Source and description of the materials to be used
- Mixture I.D. Number
- Proportions of the raw materials to be combined in the paving mixture
- Single percentage of the combined mineral aggregates passing each specified sieve
- Single percentage of asphalt by weight of the total mix to be incorporated in the completed mixture
- Single temperature at which to discharge the mixture from the plant
- Theoretical specific gravity of the mixture at the designated asphalt content
- Name of the person or agency responsible for quality control of the mixture during production

Do the following to have the formulas approved in accordance with SOP 40 “Approval of Contractor Job Mix Formulas” and to ensure their quality:

1. Submit proposed job mix formulas for review at least two weeks before beginning the mixing operations.
2. Do not start hot mix asphaltic concrete work until the Engineer has approved a job mix formula for the mixture to be used. No mixture will be accepted until the Engineer has given approval.
3. Provide mix designs for all SMA, Superpave and 4.75 mm mixes to be used. The Department will provide mix design results for other mixes to be used.
4. After a job mix formula has been approved, assume responsibility for the quality control of the mixtures supplied to the Department according to Subsection 106.01, “Source of Supply and Quantity of Materials.”

D. Quality Control Program

Submit a Quality Control Plan to the Office of Materials and Testing for approval. The Quality Control Program will be included as part of the certification in the annual plant inspection report.

400.2 Materials

Ensure materials comply with the specifications listed in Table 1.

Table 1—Materials Specifications

Material	Subsection
Asphalt Cement, Grade Specified	820.2
Coarse Aggregates for Asphaltic Concrete	802.2.02

Fine Aggregates for Asphaltic Concrete	802.2.01
Mineral Filler	883.1
Heat Stable Anti-Stripping Additive	831.2.04
Hydrated Lime	882.2.03
Silicone Fluid (When approved by the Office of Materials and Testing)	831.2.05
Bituminous Tack Coat: PG 58-22, PG 64-22, PG 67-22	820.2
Hot Mix Asphaltic Concrete Mixtures	828
Fiber Stabilizing Additives	819

When approved by the Office of Materials and Testing and required in the Contract, provide Uintaite material, hereafter referred to by the common trade name Gilsonite, as a reinforcing agent for bituminous mixtures. Supply a manufacturer's certification that the Gilsonite is a granular solid which meets the following requirements:

Softening Point (AASHTO: T-53)	300-350 °F (150-175 °C)
Specific Gravity, 77 °F (25 °C) (AASHTO: T-228)	1.04 ± 0.02
Flash Point, COC (AASHTO: T-48)	550 °F (290 °C) Min.
Ash Content (AASHTO: T-111)	1.0% Max.
Penetration, 77 °F (25 °C), 100 gm., 5 sec. (AASHTO: T-49)	0

400.2.01 Delivery, Storage, and Handling

Storage of material is allowed in a properly sealed and insulated system for up to 24 hours. Ensure Stone Matrix Asphalt (SMA), Open-Graded Friction Course (OGFC), or Porous European Mix (PEM) mixtures are not stored more than 12 hours. Mixtures other than SMA, OGFC, or PEM may be stored up to 72 hours in a sealed and insulated system, equipped with an auxiliary inert gas system, with the Engineer's approval. Segregation, lumpiness, drain-down, or stiffness of stored mixture is cause for rejection of the mixture. The Engineer will not approve using a storage or surge bin if the mixture segregates, loses excessive heat, or oxidizes during storage.

The Engineer may obtain mixture samples or recover asphalt cement according to GDT 119. AASHTO T315, AASHTO T 202 and AASHTO T 49 will be used to perform viscosity and penetration tests to determine how much asphalt hardening has occurred.

A. Vehicles for Transporting and Delivering Mixtures

Ensure trucks used for hauling bituminous mixtures have tight, clean, smooth beds.

Follow these guidelines when preparing vehicles to transport bituminous mixtures:

1. Use an approved releasing agent from QPL 39 in the transporting vehicle beds, if necessary, to prevent the mixture from sticking to the bed. Ensure the releasing agent is not detrimental to the mixture. When applying the agent, drain the excess agent from the bed before loading. Remove from the project any transporting vehicles determined to contain unapproved releasing agents.
2. Protect the mixture with a waterproof cover large enough to extend over the sides and ends of the bed. Securely fasten the waterproof cover before the vehicle begins moving.
3. Insulate the front end and sides of each bed with an insulating material with the following specifications:
 - Consists of builders insulating board or equivalent
 - Has a minimum "R" value of 4.0
 - Can withstand approximately 400 °F (200 °C) temperatures

Install the insulating material so it is protected from loss and contamination. A "Heat Dump Body" may be used in lieu of insulation of the bed. "Heat Dump Body" refers to any approved transport vehicle capable of diverting engine exhaust and transmitting heat evenly throughout the dump body to keep asphalt at required temperature. Mark the "Heat Dump Body" clearly with "OPEN" and "CLOSE" position at the exhaust diverter. Install a padlock and lock it in the "OPEN" position when the "Heat Dump Body" is used to transport bituminous mixtures.

4. Mark each transporting vehicle with a clearly visible identification number.
5. Create a hole in each side of the bed so the temperature of the loaded mixture can be checked. Ensure the placement of these holes are located to assure the thermometer is being placed in the hot mix asphaltic concrete mixtures.

Ensure the mixture is delivered to the roadway at a temperature within ± 20 °F (± 11 °C) of the temperature on the job mix formula.

If the Engineer determines a truck may be hazardous to the Project or adversely affect the quality of the work, remove the truck from the project.

B. Containers for Transporting, Conveying, and Storing Bituminous Material

To transport, convey, and store bituminous material, use containers free of foreign material and equipped with sample valves. Bituminous material will not be accepted from conveying vehicles if material has leaked or spilled from the containers.

400.3 Construction Requirements

400.3.01 Personnel

General Provisions 101 through 150.

400.3.02 Equipment

Hot mix asphaltic concrete plants producing mix for Department use are governed by Quality Assurance for Hot Mix Asphaltic Concrete Plants in Georgia, Laboratory Standard Operating Procedure No. 27.

The Engineer will approve the equipment used to transport and construct hot mix asphaltic concrete. Ensure the equipment is in satisfactory mechanical condition and can function properly during production and placement operations. Place the following equipment at the plant or project site:

A. Field Laboratory

Provide a field laboratory according to Section 152.

B. Plant Equipment

1. Scales

Provide scales as follows:

- a. Furnish (at the Contractor's expense) scales to weigh bituminous plant mixtures, regardless of the measurement method for payment.
- b. Ensure the weight measuring devices provide documentation complying with Subsection 109.01, "Measurement and Quantities."
- c. Provide weight devices recording the mixture net weights delivered to the truck when not using platform scales. A net weight system will include, but is not limited to:
 - Hopper or batcher-type weight systems delivering asphaltic mixture directly to the truck
 - Fully automatic batching equipment with a digital recording device
- d. Use a net weight printing system only with automatic batching and mixing systems approved by the Engineer.
- e. Ensure the net weight scale mechanism or device manufacturer, installation, performance, and operation meets the requirements in Subsection 109.01, "Measurement and Quantities"
- f. Provide information on the Project tickets according to Department of Transportation SOP-15.

2. Time-Locking Devices

Furnish batch type asphalt plants with automatic time-locking devices controlling the mixing time automatically. Construct these devices to ensure the operator cannot shorten or eliminate any portion of the mixing cycle.

3. Surge- and Storage-Systems

Provide surge and storage bins as follows:

- a. Ensure bins for mixture storage are insulated and have a working seal, top and bottom, to prevent outside air infiltration and to maintain an inert atmosphere during storage. Bins not intended as storage bins may be used as

surge bins to hold hot mixtures for part of the working day. However, empty these surge bins completely at the end of the working day.

- b. Ensure surge and storage bins can retain a predetermined minimum level of mixture in the bin when the trucks are loaded.
- c. Ensure surge and storage systems do not contribute to mix segregation, lumpiness, drain-down, or stiffness.
- d. Ensure the scale mechanism or device manufacture, installation, performance, and operation meets the requirements in Subsection 109.01 "Measurement and Quantities".

4. Controls for Dust Collector Fines

Control dust collection as follows:

- a. When collecting airborne aggregate particles and returning them to the mixture, have the return system meter all or part of the collected dust uniformly into the aggregate mixture and waste the excess. The collected dust percentage returned to the mixture is subject to the Engineer's approval.
- b. When the collected dust is returned directly to the hot aggregate flow, interlock the dust feeder with the hot aggregate flow and meter the flow to maintain a constant, proportioned and uniform flow.

5. Mineral Filler Supply System

When mineral filler is required as a mixture ingredient:

- a. Use a separate bin and feed system to store and proportion the required quantity into the mixture with uniform distribution.
- b. Control the feeder system with a proportioning device meeting these specifications:
 - Is accurate to within ± 10 percent of the filler required
 - Has a convenient and accurate means of calibration
 - Interlocks with the aggregate feed or weigh system to maintain the correct proportions for all rates of production and batch sizes
- c. Provide flow indicators or sensing devices for the mineral filler system and interlock them with the plant controls to interrupt the mixture production if mineral filler introduction fails to meet the required target value after no longer than 60 seconds.
- d. Add mineral filler to the mixture as follows, according to the plant type:
 - Batch Type Asphalt Plant. Add mineral filler to the mixture in the weigh hopper.
 - Continuous Plant Using Pugmill Mixers. Feed the mineral filler into the hot aggregate before it is introduced into the mixer to ensure dry mixing is accomplished before the bituminous material is added.
 - Continuous Plants Using the Drier-Drum Mixers. Add the mineral filler to ensure dry mixing is accomplished before the bituminous material is added and ensure the filler does not become entrained into the air stream of the drier.

6. Hydrated Lime Treatment System

When hydrated lime is required as a mixture ingredient:

- a. Use a separate bin and feed system to store and proportion the required quantity into the mixture.
- b. Ensure the aggregate is uniformly coated with hydrated lime aggregate before adding the bituminous material to the mixture. Ensure the addition of hydrated lime will not become entrained in the exhaust system of the drier or plant.
- c. Control the feeder system with a proportioning device meeting these specifications:
 - Is accurate to within ± 10 percent of the amount required
 - Has a convenient and accurate means of calibration
 - Interlocks with the aggregate feed or weigh system to maintain the correct proportions for all rates of production and batch sizes and to ensure mixture produced is properly treated with lime
- d. Provide flow indicators or sensing devices for the hydrated lime system and interlock them with the plant controls to interrupt mixture production if hydrated lime introduction fails to meet the required target value after no longer than 60 seconds.

7. Net Weight Weighing Mechanisms

Certify the accuracy of the net weight weighing mechanisms by an approved registered scale serviceperson at least once every 6 months. Check the accuracy of net weight weighing mechanisms at the beginning of Project production and thereafter as directed by the Engineer. Check mechanism accuracy as follows:

- a. Weigh a load on a set of certified commercial truck scales. Ensure the difference between the printed total net weight and weight obtained from the commercial scales is no greater than 4 lbs/1,000 lbs (4 kg/Mg) of load.
Check the accuracy of the bitumen scales as follows:
 - Use standard test weights.
 - If the checks indicate printed weights are out of tolerance, have a registered scale serviceperson check the batch scales and certify the accuracy of the printer.
 - While the printer system is out of tolerance and before its adjustment, continue production only if using a set of certified truck scales to determine the truck weights.
- b. Ensure plants using batch scales maintain ten 50 lb (25 kg) standard test weights at the plant site to check batching scale accuracy.
- c. Ensure plant scales used only to proportion mixture ingredients, and not to determine pay quantities, are within two percent throughout the range.

8. Fiber Supply System

When stabilizing fiber is required as a mixture ingredient:

- a. Use a separate feed system to store and proportion by weight the required quantity into the mixture with uniform distribution.
- b. Control the feeder system with a proportioning device meeting these Specifications:
 - Is accurate to within ± 10 percent of the amount required. Automatically adjusts the feed rate to maintain the material within this tolerance at all times
 - Has a convenient and accurate means of calibration
 - Provide in-process monitoring, consisting of either a digital display of output or a printout of feed rate, in pounds (kg) per minute, to verify feed rate
 - Interlocks with the aggregate feed or weigh system to maintain the correct proportions for all rates of production and batch sizes
- c. Provide flow indicators or sensing devices for the fiber system and interlock them with the plant controls to interrupt the mixture production if fiber introduction fails or if the output rate is not within the tolerances given above.
- d. Introduce the fiber as follows:
 - When a batch type plant is used, add the fiber to the aggregate in the weigh hopper. Increase the batch dry mixing time by 8 to 12 seconds from the time the aggregate is completely emptied into the mixer to ensure the fibers are uniformly distributed prior to the injection of asphalt cement into the mixer.
 - When a continuous or drier-drum type plant is used, add the fiber to the aggregate and uniformly disperse prior to the injection of asphalt cement. Ensure the fibers will not become entrained in the exhaust system of the drier or plant.

9. Crumb Rubber Modifier Supply System

When specified, crumb rubber modifier may be substituted at the Contractor's discretion to produce a PG 76-22 asphaltic cement at the production facility in accordance with Section 820:

- a. Use a separate feed system to store and proportion by weight of the total asphaltic cement, the required percentage of crumb rubber into the mixture.
- b. Control the feeder system with a proportioning device meeting these Specifications:
 - Is accurate to within ± 6 percent of the amount required. Automatically adjusts the feed rate to maintain the material within this tolerance at all times.
 - Has a convenient and accurate means of calibration.

- Provide in-process monitoring, consisting of either a digital display of output or a printout of feed rate, in pounds per minute, to verify feed rate. **Ensure** the supply system reports the feed in 1 lb (454 gr.) increments using load cells enabling the user to monitor the depletion of the modifier. Monitoring the system volumetrically will not be allowed.
 - Interlocks with the aggregate weigh system and asphaltic cement pump to maintain the correct proportions for all rates of production and batch sizes.
- c. Provide flow indicators or sensing devices for the system and interlock them with the plant controls to interrupt the mixture production if the crumb rubber introduction output rate is not within the ± 6 percent tolerance given above. This interlock will immediately notify the operator if the targeted rate exceeds introduction tolerances. All plant production will cease if the introduction rate is not brought back within tolerance after 30 seconds. When the interlock system interrupts production and the plant has to be restarted, upon restarting operations; ensure the modifier system runs until a uniform feed can be observed on the output display. Ensure all mix produced prior to obtaining a uniform feed is rejected.
- d. Introduce the crumb rubber modifier as follows:
- When a batch type plant is used, add the rubber to the aggregate in the weigh hopper. Increase the batch dry mixing time by 15 to 20 seconds from the time the aggregate is completely emptied into the mixer to ensure the modifiers are uniformly distributed prior to the injection of asphalt cement into the mixer. Increase the batch wet mix time by 15 to 20 seconds to ensure the crumb rubber modifier is uniformly blended with the asphaltic cement.
 - When a continuous or drier-drum type plant is used, add the rubber to the aggregate and uniformly disperse prior to the injection of asphalt cement. The point of introduction in the drum mixer will be approved by the Engineer prior to production. Ensure the crumb rubber modifier will not become entrained in the exhaust system of the drier or plant and will not be exposed to the drier flame at any point after induction.
- e. No separate measurement and payment will be made if Contractor elects to utilize crumb rubber.

C. Equipment at Project Site

1. Cleaning Equipment

Provide sufficient hand tools and power equipment to clean the roadway surface before placing the bituminous tack coat. Use power equipment complying with Subsection 424.3.02.F, "Power Broom and Power Blower."

2. Pressure Distributor

To apply the bituminous tack coat, use a pressure distributor complying with Subsection 424.3.02.B, "Pressure Distributor."

3. Bituminous Pavers

To place hot mix asphaltic concrete, use bituminous pavers that can spread and finish courses that are:

- As wide and deep as indicated on the Plans
 - True to line, grade, and cross section
 - Smooth
 - Uniform in density and texture
- a. Continuous Line and Grade Reference Control. Furnish, place, and maintain the supports, wires, devices, and materials required to provide continuous line and grade reference control to the automatic paver control system.
- b. Automatic Screed Control System. Equip the bituminous pavers with an automatic screed control system actuated from sensor-directed mechanisms or devices that will maintain the paver screed at a pre-determined transverse slope and elevation to obtain the required surface.
- c. Transverse Slope Controller. Use a transverse slope controller capable of maintaining the screed at the desired slope within ± 0.1 percent. Do not use continuous paving set-ups resulting in unbalanced screed widths or off-center breaks in the main screed cross section unless approved by the Engineer.
- d. Screed Control. Equip the paver to permit the following four modes of screed control. Ensure the method used is approved by the Engineer.

- Automatic grade sensing and slope control
- Automatic dual grade sensing
- Combination automatic and manual control
- Total manual control

Ensure the controls are referenced with a taut string or wire set to grade, or with a ski-type device or mobile reference at least 30 ft (9 m) long when using a conventional ski. Approved non-contacting laser or sonar-type skis listed on QPL 91 “Georgia’s List of Approved Non-contacting Laser and Sonar-type Electronic Grade and Slope Controls” may be used in lieu of conventional 30 ft (9m) skis. Under limited conditions, a short ski or shoe may be substituted for a long ski on the second paver operating in tandem, or when the reference plane is a newly placed adjacent lane.

Automatic screed control is required on all Projects; however, when the Engineer determines that Project conditions prohibit the use of such controls, the Engineer may waive the grade control, or slope control requirements, or both.

- e. Paver Screed Extension. When the laydown width requires a paver screed extension, use bolt-on screed extensions to extend the screeds, or use an approved mechanical screed extension device. When the screed is extended, add auger extensions to assure a length of no more than 18 inches (0.5 m) from the auger to the end gate of the paver. Auger extensions may be omitted when paving variable widths. Ensure the paver is equipped with tunnel extensions when the screed and augers are extended.

NOTE: Do not use extendible strike-off devices instead of approved screed extensions. Only use a strike-off device in areas that would normally be luted in by hand labor.

4. Compaction Equipment

Ensure that the compaction equipment is in good mechanical condition and can compact the mixture to the required density. The compaction equipment number, type, size, operation, and condition is subject to the Engineer’s approval

5. Materials Transfer Vehicle (MTV)

- a. Use a Materials Transfer Vehicle (MTV) when placing asphaltic concrete mixtures on Projects on the state route system with the following conditions. If a project fails to meet any one of the following conditions, the MTV’s use is not required other than during the placement of SMA, PEM and OGFC mixtures. MTVs are required during the placement of SMA, PEM and OGFC mixtures regardless of ADT, project length and mixture tonnage unless waived at the discretion of the Office of Materials and Testing.

1) When to use:

- The ADT is equal to or greater than 6000
- The project length is equal to or greater than 3000 linear feet (915 linear meters)
- The total tonnage (megagrams) of all asphaltic concrete mixtures is greater than 2000 tons (1815 Mg)

2) Where to use:

- Mainline of the traveled way
- Collector/distributor (C/D) lanes on Interstates and limited access roadways
- Leveling courses at the Engineer’s discretion

3) Do not use the MTV for the following conditions:

- A resurfacing project that only 9.5 mm mix is required.
- A project with lane width that is equal or less than 11 feet (3.4 m).
- A passing lane only project.
- When noted on the plans.

- b. Ensure the MTV and conventional paving equipment meet the following requirements:

1) MTV

- Has a truck unloading system which receives mixture from the hauling equipment and independently deliver mixtures from the hauling equipment to the paving equipment.
 - Has mixture remixing capability approved by the Office of Materials and Testing and is listed on QPL 88 “Georgia’s List of Approved Materials Transfer Vehicles”.
 - Provides to the paver a homogeneous, non-segregated mixture of uniform temperature with no more than 20 °F(11 °C) difference between the highest and lowest temperatures when measured transversely across the width of the mat in a straight line at a distance of one foot to twenty-five feet (0.3 m to 7.6 m) from the screed while the paver is operating. Ensure that the MTV is capable of providing the paver a consistent material flow that is sufficient to prevent the paver from stopping between truck exchanges.
- 2) Conventional Paving Equipment
- Has a paver hopper insert with a minimum capacity of 14 tons (13 Mg) installed in the hopper of conventional paving equipment when an MTV is used.
- c. If the MTV malfunctions during spreading operations, discontinue placement of hot mix asphaltic concrete after there is sufficient mix placed to maintain traffic in a safe manner. However, placement of hot mix asphaltic concrete in a lift not exceeding 2 in. (50 mm) may continue until any additional hot mix in transit at the time of the malfunction has been placed. Cease spreading operations thereafter until the MTV is operational.
- d. Ensure the MTV is empty when crossing a bridge and is moved across without any other Contractor vehicles or equipment on the bridge. Move the MTV across a bridge in a travel lane and not on the shoulder. Ensure the speed of the MTV is no greater than 5 mph (8 kph) without any acceleration or deceleration while crossing a bridge.

400.3.03 Preparation

A. Prepare Existing Surface

Prepare the existing surface as follows:

1. Clean the Existing Surface. Before applying hot mix asphaltic concrete pavement, clean the existing surface to the Engineer’s satisfaction.
2. Patch and Repair Minor Defects
Before placing leveling course:
 - a. Correct potholes and broken areas requiring patching in the existing surface and base as directed by the Engineer.
 - b. Cut out, trim to vertical sides, and remove loose material from the areas to be patched.
 - c. Prime or tack coat the area after being cleaned. Compact patches to the Engineer’s satisfaction. Material for patches does not require a job mix formula, but must meet the gradation range shown in Section 828. The Engineer must approve the asphalt content to be used.
3. Apply Bituminous Tack Coat
Apply the tack coat according to Section 413. The Engineer will determine the application rate, which must be within the limitations Table 2.

Table 2—Application Rates for Bituminous Tack, gal/yd² (L/m²)

	Minimum	Maximum
Under OGFC and PEM Mixes	0.06 (0.270)	0.08 (0.360)
All Other Mixes	0.04 (0.180)	0.06(0.270)
*On thin leveling courses and freshly placed asphaltic concrete mixes, reduce the application rate to 0.02 to 0.04 gal/yd ² (0.09 to 0.18 L/m ²).		

B. Place Patching and Leveling Course

1. When the existing surface is irregular, bring the surface area to the proper cross section and grade with a leveling course of hot mix asphaltic concrete materials.
2. Place leveling at the locations and in the amounts directed by the Engineer.
3. Use leveling course mixtures meeting the requirements of the job mix formulas defined in:
 - Subsection 400.3.05.A, “Observe Composition of Mixtures”
 - Section 828
 - Leveling acceptance schedules in Subsection 400.3.06.A, “Acceptance Plans for Gradation and Asphalt Cement Content”
4. If the leveling and patching mix type is undesignated, determine the mix type by the thickness or spread rate according to Table 3, but do not use 4.75 mm mix on interstate projects.

Table 3—Leveling and Patching Mix Types

Thickness	Rate of Spread	Type of Mix
Up to 0.75 in (19 mm)	Up to 85 lbs/yd ² (45 kg/m ²)	4.75 mm Mix or 9.5 mm Superpave Type 1
0.75 to 1.5 in (19 to 38 mm)	85 to 165 lbs/yd ² (45 to 90 kg/m ²)	9.5 mm Superpave Type 2
1.5 to 2 in (38 to 50 mm)	165 to 220 lbs/yd ² (90 to 120 kg/m ²)	12.5 mm Superpave *
2 to 2.5 in (50 to 64 mm)	220 to 275 lbs/yd ² (120 to 150 kg/m ²)	19 mm Superpave *
Over 2.5 in (64 mm)	Over 275 lbs/yd ² (150 kg/m ²)	25 mm Superpave

* These mixtures may be used for isolated patches no more than 6 in. (150 mm) deep and no more than 4 ft. (1.2 m) in diameter or length.

400.3.04 Fabrication

General Provisions 101 through 150.

400.3.05 Construction

Provide the Engineer at least one day’s notice prior to beginning construction, or prior to resuming production if operations have been temporarily suspended.

A. Observe Composition of Mixtures

1. Calibration of plant equipment

If the material changes, or if a component affecting the ingredient proportions has been repaired, replaced, or adjusted, check and recalibrate the proportions.

Calibrate as follows:

- a. Before producing mixture for the Project, calibrate by scale weight the electronic sensors or settings for proportioning mixture ingredients.
- b. Calibrate ingredient proportioning for all rates of production.

2. Mixture control

Compose hot mix asphaltic concrete from a uniform mixture of aggregates, bituminous material, and if required, hydrated lime, mineral filler, or other approved additive.

Ensure the constituents proportional to produce mixtures meeting the requirements in Section 828. The general composition limits prescribed are extreme ranges within which the job mix formula must be established. Base mixtures on a design analysis that meets the requirements of Section 828.

Ensure the field performance of the in-place mixtures meet the requirements of Subsection 828.2B for Permeability, Moisture Susceptibility, Rutting Susceptibility and Fatigue. In-place mix may be evaluated for compliance with Subsection 828.2.B at the discretion of the State Bituminous Construction Engineer under the following conditions:

- Deviates greater than 10 percent on gradation for mixture control sieves from the approved Job Mix Formula based on Acceptance or Independent Samples.
- Deviates greater than 0.7 percent in asphalt cement content from the approved Job Mix Formula based on Acceptance or Independent Samples.
- The calculated mean pavement air voids result in an adjusted pay factor less than 0.80 or any single sub lot result in mean pavement air voids exceeding 10.5 percent.
- Mix produced not using an approved mix design and/or job mix formula.

Remove and replace any material determined to not meet the requirements established in Section 828.2.B at the Contractor's expense.

If control test results show the characteristic tested does not conform to the job mix formula control tolerances given in Section 828, take immediate action to ensure that the quality control methods are effective.

Control the materials to ensure extreme variations do not occur. Maintain the gradation within the composition limits in Section 828.

B. Prepare Bituminous Material

Uniformly heat the bituminous material to the temperature specified in the job mix formula with a tolerance of ± 20 °F (± 11 °C).

C. Prepare the Aggregate

Prepare the aggregate as follows:

1. Heat the aggregate for the mixture, and ensure a mix temperature within the limits of the job mix formula.
2. Do not contaminate the aggregate with fuel during heating.
3. Reduce the absorbed moisture in the aggregate until the asphalt does not separate from the aggregate in the prepared mixture. If this problem occurs, the Engineer will establish a maximum limit for moisture content in the aggregates. When this limit is established, maintain the moisture content below this limit.

D. Prepare the Mixture

Proportion the mixture ingredients as necessary to meet the required job mix formula. Mix until a homogenous mixture is produced.

1. Add Mineral Filler

When mineral filler is used, introduce it in the proper proportions and as specified in Subsection 400.3.02.B.5, "Mineral Filler Supply System."

2. Add Hydrated Lime

When hydrated lime is included in the mixture, add it at a rate specified in Section 828 and the job mix formula. Use methods and equipment for adding hydrated lime according to Subsection 400.3.02.B.6, "Hydrated Lime Treatment System."

Add hydrated lime to the aggregate by using Method A or B as follows:

Method A—Dry Form—Add hydrated lime in its dry form to the mixture as follows, according to the type of plant:

- a. Batch Type Asphalt Plant: Add hydrated lime to the mixture in the weigh hopper or as approved and directed by the Engineer.
- b. Continuous Plant Using Pugmill Mixer: Feed hydrated lime into the hot aggregate before it is introduced into the mixer to ensure dry mixing is complete before the bituminous material is added.
- c. Continuous Plant Using Drier-Drum Mixer: Add hydrated lime so to ensure the lime will not become entrained into the air stream of the drier and to ensure thorough dry mixing will be complete before the bituminous material is added.

Method B—Lime/Water Slurry—Add the required quantity of hydrated lime (based on dry weight) in lime/water slurry form to the aggregate. This solution consists of lime and water in concentrations as directed by the Engineer. Equip the plant to blend and maintain the hydrated lime in suspension and to mix the hydrated lime with the aggregates uniformly in the proportions specified.

3. Add Stabilizing Fiber

When stabilizing fiber is included in the mixture, add stabilizing fiber at a rate specified in Section 819 and the Job Mix Formula. Introduce it as specified in Subsection 400.3.02.B.8, “Fiber Supply System.”

4. Add Gilsonite Modifier

When approved by the Office of Materials and Testing and required by the Contract, add the Gilsonite modifier to the mixture at a rate to ensure eight percent by weight of the asphalt cement is replaced by Gilsonite. Use either PG 64-22 or PG 67-22 asphalt cement as specified in Subsection 820.2.01. Provide suitable means to calibrate and check the rate of Gilsonite being added. Introduce Gilsonite modifier by either of the following methods.

- a. For batch type plants, incorporate Gilsonite into the pugmill at the beginning of the dry mixing cycle. Increase the dry mix cycle by a minimum of 10 seconds after the Gilsonite is added and prior to introduction of the asphalt cement. For this method, supply Gilsonite in plastic bags to protect the material during shipment and handling and store the modifier in a waterproof environment. Ensure the bags are capable of being completely melted and uniformly blended into the combined mixture.

Gilsonite may also be added through a mineral filler supply system as described in Subsection 400.3.02.B.5, “Mineral Filler Supply System.” Ensure the system is capable of injecting the modifier into the weigh hopper near the center of the aggregate batching cycle so the material can be accurately weighed.

- b. For drum drier plants, add Gilsonite through the recycle ring or through an acceptable means which will introduce the Gilsonite prior to the asphalt cement injection point. The modifier must proportionately feed into the drum mixer at the required rate by a proportioning device which shall be accurate within ± 10 percent of the amount required. Ensure the entry point is away from flames and the Gilsonite will not be caught up in the air stream and exhaust system.

5. Materials from Different Sources

Do not use mixtures prepared from aggregates from different sources intermittently. This will cause the color of the finished pavement to vary.

E. Observe Weather Limitations

Do not mix and place asphaltic concrete if the existing surface is wet or frozen. Do not lay asphaltic concrete OGFC mix or PEM at air temperatures below 60 °F (16 °C). When using a MTV, OGFC mix or PEM may be placed at 55 °F (13 °C) when approved by the Engineer. For other courses, follow the temperature guidelines in the following table:

Table 4—Lift Thickness Table

Lift Thickness	Minimum Temperature
1 in (25 mm) or less	55 °F (13 °C)
1.1 to 2 in (26 mm to 50 mm)	45 °F (8 °C)
2.1 to 3 in (51 mm to 75 mm)	40 °F (4 °C)
3.1 to 4 in (76 mm to 100 mm)	35 °F (2 °C)
4.1 to 8 in (101 mm to 200 mm)	32 °F (0 °C) and rising. Base Material must not be frozen.

F. Perform Spreading and Finishing

Spread and finish the course as follows:

- 1. Determine the course’s maximum compacted layer thickness by the type mix being used according to Table 5.

Table 5—Maximum Layer Thickness

Mix Type	Minimum Layer Thickness	Maximum Layer Thickness	Maximum Total Thickness
25 mm Superpave	2 1/2 in (64 mm)	4 in (100 mm) *	—
19 mm Superpave	1 3/4 in (44 mm)	3 in (75 mm) *	—
12.5 mm Superpave	1 3/8 in (35 mm)	2 1/2 in (64 mm)**	8 in (200 mm)
9.5 mm Superpave Type 2	1 1/8 in.(28 mm)	1 1/2 in (38 mm)**	4 in (100 mm)
9.5 mm Superpave Type 1	7/8 in (22 mm)	1 1/4 in (32 mm)	4 in (100 mm)
4.75 mm Mix	3/4 in (19 mm)	1 1/8 in (28 mm)	2 in (50 mm)
9.5 mm OGFC	55 lbs/yd ² (30 kg/m ²)	65 lbs/yd ² (36 kg/m ²)	—
12.5 mm OGFC	85 lbs/yd ² (47 kg/m ²)	95 lbs/yd ² (53 kg/m ²)	—
12.5 mm PEM	110 lbs/yd ² (80 kg/m ²)	165 lbs/yd ² (90 kg/m ²)	—
9.5 mm SMA	1 1/8 in (28 mm)	1 1/2 in (38 mm)	4 in (100 mm)
12.5 mm SMA	1 3/8 in (35 mm)	3 in (75 mm)	6 in (150 mm)
19 mm SMA	1 3/4 in (44 mm)	3 in (75 mm)	—

* Allow up to 6 in (150 mm) per lift on trench widening. **Place 9.5 mm Superpave and 12.5 mm Superpave up to 4 in (100 mm) thick for driveway and side road transition.

2. Unload the mixture into the paver hopper or into a device designed to receive the mixture from delivery vehicles.
3. Except for leveling courses, spread the mixture to the loose depth for the compacted thickness or the spread rate. Use a mechanical spreader true to the line, grade, and cross section specified.
4. For leveling courses, use a motor grader equipped with a spreader box and smooth tires to spread the material or use a mechanical spreader meeting the requirements in Subsection 400.3.02.C, "Equipment at Project Site."
5. Obtain the Engineer's approval for the sequence of paving operations, including paving the adjoining lanes. Minimize tracking tack onto surrounding surfaces.
6. Ensure the outside edges of the pavement being laid are aligned and parallel to the roadway center line.
7. For New Construction or Resurfacing Contracts containing multiple lifts or courses, arrange the width of the individual lifts so the longitudinal joints of each successive lift are offset from the previous lift at least 1 ft (300 mm). This requirement does not apply to the lift immediately over thin lift leveling courses.
Ensure the longitudinal joint(s) in the surface course and the mix immediately underneath asphaltic concrete OGFC or PEM are at the lane line(s).

NOTE: Perform night work with artificial light provided by the Contractor and approved by the Engineer.

8. Where mechanical equipment cannot be used, spread and rake the mixture by hand. Obtain the Engineer's approval of the operation sequence, including compactive methods, in these areas.
9. Keep small hand raking tools clean and free from asphalt build up. Do not use fuel oil or other harmful solvents to clean tools during the work.
10. Do not use mixture with any of these characteristics:
 - Segregated
 - Nonconforming temperature
 - Deficient or excessive asphalt cement content
 - Otherwise unsuitable to place on the roadway in the work
11. Remove and replace mixture placed on the roadway that the Engineer determines has unacceptable blemish levels from segregation, raveling, streaking, pulling and tearing, or other deficient characteristics. Replace with acceptable mixture at the Contractor's expense. Do not continually place mixtures with deficiencies.

Do not place subsequent course lifts over another lift or course placed on the same day while the temperature of the previously placed mix is 140 °F (60 °C) or greater.

12. Obtain the Engineer's approval of the material compaction equipment. Perform the rolling as follows:
 - a. Begin the rolling as close behind the spreader as possible without causing excessive distortion of the asphaltic concrete surface.
 - b. Continue rolling until roller marks are no longer visible.
 - c. Use pneumatic-tired rollers with breakdown rollers on all courses except asphaltic concrete OGFC, PEM and SMA or other mixes designated by the Engineer.
13. If applicable, taper or "feather" asphaltic concrete from full depth to a depth no greater than 0.5 in (13 mm) along curbs, gutters, raised pavement edges, and areas where drainage characteristics of the road must be retained. The Engineer will determine the location and extent of tapering.

G. Maintain Continuity of Operations

Coordinate plant production, transportation, and paving operations to maintain a continuous operation. If the spreading operations are interrupted, construct a transverse joint if the mixture immediately behind the paver screed cools to less than 250 °F (120 °C).

H. Construct the Joints

1. Construct Transverse Joints
 - a. Construct transverse joints to facilitate full depth exposure of the course before resuming placement of the affected course.
 - b. Properly clean and tack the vertical face of the transverse joint before placing additional material.

NOTE: Never burn or heat the joint by applying fuel oil or other volatile materials.

- c. Straightedge transverse joints immediately after forming the joint.
 - d. Immediately correct any irregularity that exceeds 3/16 in. in 10 ft (5 mm in 3 m).
2. Construct Longitudinal Joints

Clean and tack the vertical face of the longitudinal joint before placing adjoining material. Construct longitudinal joints so that the joint is smooth, well sealed, and bonded.

3. Construction Joint Detail for OGFC and PEM Mixtures

In addition to meeting joint requirements described above, construct joints and transition areas for 12.5 mm OGFC and 12.5 mm PEM mixtures as follows:

- a. For projects which do not have milling included as a pay item:
 - 1) Place OGFC mixture meeting gradation requirements of 9.5 mm OGFC as specified in Section 828 on entrance and exit ramp gore areas and end of project construction joints.
 - Taper mixture from 3/8 in (10 mm) at end of project to full plan depth within maximum distance of spread for one load of mixture
 - Taper mixture placed on gore areas from thickness of the edge of the mainline to 3/8 in (10 mm) at the point of the ramp transverse joint.
 - 2) Construct the ramp transverse joint at the point specified in the plans or as directed by the Engineer.
 - 3) Mixture placed in the transition and gore areas will be paid for at the contract unit price for 12.5 mm OGFC or 12.5 mm PEM as applicable.
- b. For projects which have milling included as a pay item:
 - 1) Taper milling for a distance of no less than 50 ft (15 m) to a depth of 2 1/4 in (59 mm) at the point of the transverse joint
 - 2) Taper thickness, if needed, of the dense-graded surface mix within the 50 ft (15 m) distance to 1 1/2 in (40 mm) at the point of the transverse joint
 - 3) Taper thickness of the 12.5 mm OGFC or 12.5 mm PEM to 3/4 in (19 mm) to ensure the material ties in at grade level with the existing surface at the point of the transverse joint

I. Protect the Pavement

Protect sections of the newly finished pavement from traffic until the traffic will not mar the surface or alter the surface texture. If directed by the Engineer, use artificial methods to cool the newly finished pavement to open the pavement to traffic more quickly.

J. Modify the Job Mix Formula

If the Engineer determines that undesirable mixture or mat characteristics are being obtained, the job mix formula may require immediate adjustment.

400.3.06 Quality Acceptance

A. Acceptance Plans for Gradation and Asphalt Cement Content

The Contractor will randomly sample and test mixtures for acceptance on a lot basis. The Department will monitor the Contractor testing program and perform comparison and quality assurance testing. The Contractor's Quality Control Technicians shall participate in the Department's Independent Assurance Systems Basis Program.

1. Determine Lot Amount

A lot consists of the tons (megagrams) of asphaltic concrete produced and placed each production day. If this production is less than 500 tons (500 Mg), or its square yard (meter) equivalent, production may be incorporated into the next working day. The Engineer may terminate a lot when a pay adjustment is imminent if a plant or materials adjustment resulting in a probable correction has been made. Terminate all open lots at the end of the month, except for materials produced and placed during the adjustment period. The lot will be terminated as described in Subsection 400.5.01, "Adjustments".

If the final day's production does not constitute a lot, the production may be included in the lot for the previous day's run; or, the Engineer may treat the production as a separate lot with a corresponding lower number of tests.

2. Determine Lot Acceptance

Determine lot acceptance as found in Subsection 400.5.01, "Adjustments."

The Department will perform the following task:

Determine the pay factor by using the mean of the deviations from the job mix formula of the tests in each lot and apply it to Table 10 Mixture Acceptance Schedule for Surface Mixes or Table 11 Mixture Acceptance Schedule for Subsurface Mixes, whichever is appropriate. This mean will be determined by averaging the actual numeric value of the individual deviations from the job mix formula, disregarding whether the deviations are positive or negative amounts. Do not calculate lot acceptance using test results for materials not used in the Work. Determine the pay factor for each lot by multiplying the contract unit price by the appropriate pay factor from the Mixture Acceptance Schedule - Table 10 or Table 11. When two or more pay factors for a specific lot are less than 1.0, determine the adjusted payment by multiplying the contract unit price by the lowest pay factor.

If the mean of the deviations from the job mix formula of the lot acceptance tests for a control sieve or for asphalt cement content exceeds the tolerances established in the appropriate Mixture Acceptance Schedule, and if the Engineer determines that the material need not be removed and replaced, the lot may be accepted at an adjusted unit price as determined by the Engineer. If the Engineer determines that the material is not acceptable to leave in place, the materials shall be removed and replaced at the Contractor's expense.

3. Provide Quality Control Program

Provide a Quality Control Program as established in SOP 27 which includes:

- Assignment of quality control responsibilities to specifically named individuals who have been certified by the Office of Materials and Testing
- Provisions for prompt implementation of control and corrective measures
- Provisions for communication with Project Manager, Bituminous Technical Services Engineer, and Testing Management Operations Supervisor at all times
- Provisions for reporting all test results daily through the Office of Materials and Testing computerized Field Data Collection System; other checks, calibrations and records will be reported on a form developed by the Contractor and will be included as part of the project records
- Notification in writing of any change in quality control personnel

a. Certification Requirements:

- Use laboratory and testing equipment certified by the Department. (Laboratories which participate in and maintain AASHTO accreditation for testing asphaltic concrete mixtures will be acceptable in lieu of Departmental certification.)
- Provide certified quality control personnel to perform the sampling and testing. A Quality Control Technician (QCT) may be certified at three levels:
 - 1) Temporary Certification – must be a technician trainee who shall be given direct oversight by a certified Level 1 or Level 2 QCT while performing acceptance testing duties during the first 5 days of training. The trainee must complete qualification requirements within 30 Georgia Department of Transportation funded production days after being granted temporary certification. A trainee who does not become qualified within 30 Georgia Department of Transportation funded production days will not be re-eligible for temporary certification. A certified Level 1 or Level 2 QCT shall be at the plant at all times during production and shipment of mixture to monitor work of the temporarily certified technician.
 - 2) Level 1 – must demonstrate they are competent in performing the process control and acceptance tests and procedures related to hot mix asphalt production and successfully pass a written exam.
 - 3) Level 2 – must meet Level 1 requirements and must be capable of and responsible for making process control adjustments, and successfully pass a written exam.
 - Technician certification is valid for 3 years from the date on the technician’s certificate unless revoked or suspended. Eligible technicians may become certified through special training and testing approved by the Office of Materials and Testing. Technicians who lose their certification due to falsification of test data will not be eligible for recertification in the future unless approved by the State Materials and Testing Engineer.

b. Quality Control Management

- 1) Designate at least one Level 2 QCT as manager of the quality control operation. Ensure the Quality Control Manager meets the following requirements:
 - Be accountable for actions of other QCT personnel
 - Ensure all applicable sampling requirements and frequencies, test procedures, and Standard Operating Procedures are adhered to
 - Ensure all reports, charts, and other documentation is completed as required
- 2) Provide QCT personnel at the plant as follows:
 - If daily production for all mix types is to be greater than 250 tons (megagrams), have a QCT person at the plant at all times during production and shipment of mixture until all required acceptance tests have been completed
 - If daily production for all mix types will not be greater than 250 tons (megagrams) a QCT may be responsible for conducting tests at up to two plants, subject to random number sample selection
 - Have available at the plant or within immediate contact by phone or radio a Level 2 QCT responsible for making prompt process control adjustments as necessary to correct the mix
- 3) Sampling, Testing, and Inspection Requirements.

Provide all sample containers, extractants, forms, diaries, and other supplies subject to approval of the Engineer.

Perform daily sampling, testing, and inspection of mixture production that meets the following requirements:

 - a) Randomly sample mixtures according to GSP 15, and GDT 73 (Method C) and test on a lot basis. In the event less than the specified number of samples are taken, obtain representative 6 in (150 mm) cores from the roadway at a location where the load not sampled was placed. Take enough cores to ensure minimum sample size requirements are met for each sample needed.
 - b) Maintain a printed copy of the computer generated random sampling data as a part of the project records.

- c) Perform sampling, testing, and inspection duties of GSP 21.
 - d) Perform extraction or ignition test (GDT 83 or GDT 125) and extraction analysis (GDT 38). If the ignition oven is used, a printout of sample data including weights becomes a part of the project records. For asphalt cement content only, digital printouts of liquid asphalt cement weights may be substituted in lieu of an extraction test for plants with digital recorders. Calculate the asphalt content from the ticket representing the mixture tested for gradation.
 - e) Save extracted aggregate, opposite quarters, and remaining material (for possible referee testing) of each sample as follows:
 - Store in properly labeled, suitable containers
 - Secure in a protected environment
 - Store for three working days. If not obtained by the Department, within three days they may be discarded in accordance with GSP 21.
 - f) Add the following information on load tickets from which a sample or temperature check is taken:
 - Mixture temperature
 - Signature of the QCT person performing the testing
 - g) Calibrate the lime system when hydrated lime is included in the mixture:
 - Perform a minimum of twice weekly during production
 - Post results at the plant for review
 - Provide records of materials invoices upon request (including asphalt cement, aggregate, hydrated lime, etc.)
 - h) Take action if acceptance test results are outside Mixture Control Tolerances of Section 828.
 - One sample out of tolerance
 - (1) Contact Level 2 - QCT to determine if a plant adjustment is needed
 - (2) Immediately run a process control sample. Make immediate plant adjustments if this sample is also out of tolerance
- NOTE: Determine mixture temperature at least once per hour of production for OGFC and PEM mixes.**
- (3) Test additional process control samples as needed to ensure corrective action taken appropriately controls the mixture
 - Two consecutive acceptance samples of the same mix type out of tolerance regardless of Lot or mix design level, or three consecutive acceptance samples out of tolerance regardless of mix type
 - (1) Stop plant production immediately
 - (2) Reject any mixture in storage:
 - Deviating more than 10 percent in gradation from the job mix formula based on the acceptance sample
 - Deviating more than 0.7 percent in asphalt content from the job mix formula based on the acceptance sample
 - (3) Make a plant correction to any mix type out of tolerance prior to resuming production
 - Do not send any mixture to the project before test results of a process control sample meets Mixture Control Tolerances
 - Reject any mixture produced at initial restarting that does not meet Mixture Control Tolerances
- 4) Comparison Testing and Quality Assurance Program
- Periodic comparison testing by the Department will be required of each QCT to monitor consistency of equipment and test procedures. The Department will take independent samples to monitor the Contractor's quality control program.

a) Comparison Sampling and Testing

Retain samples for comparison testing and referee testing if needed as described in Subsection 400.3.06.A.3.b.3. Discard these samples only if the Contractor's acceptance test results meet a 1.00 pay factor and the Department does not procure the samples within three working days.

The Department will test comparison samples on a random basis. Results will be compared to the respective contractor acceptance tests and the maximum difference is as follows:

Table 6—Allowable Percent Difference Between Department and Contractor Acceptance Tests

<u>SIEVE SIZE</u>	<u>SURFACE</u>	<u>SUB-SURFACE</u>
1/2 in. (12.5 mm)		4.0%
3/8 in. (9.5 mm)	3.5%	4.0%
No. 4 (4.75 mm)	3.5%	3.5%
No. 8 (2.36 mm)	2.5%	3.0%
No. 200 (75 μm)	2.0%	2.0%
A.C.	0.4%	0.5%

(1) If test comparisons are within these tolerances:

- Continue production
- Use the Contractor's tests for acceptance of the lot

(2) If test comparisons are not within these tolerances:

- Another Departmental technician will test the corresponding referee sample
- Results of the referee sample will be compared to the respective contractor and Departmental tests using the tolerance for comparison samples given above.
 - (a) If referee test results are within the above tolerances when compared to the Contractor acceptance test, use the Contractor's test for acceptance of the effected lot.
 - (b) If referee test results are not within the above tolerances when compared to the Contractor acceptance test, the Department will review the Contractor's quality control methods and determine if a thorough investigation is needed.

b) Independent Verification Sampling and Testing

- (1) Randomly take a minimum of two independent samples from the lesser of five days or five lots of production regardless of mix type or number of projects.
- (2) Compare test deviation from job mix formula to Mixture Control Tolerances in Section 828. If results are outside these tolerances, another sample from the respective mix may be taken.

NOTE: For leveling courses less than 110 lb/yd² (60 kg/m²) having quality assurance test results outside the Mixture Control Tolerances of Section 828, use the Department's test results only and applicable pay factors will apply.

- Take random samples from throughout the subject lot(s) as established in Subsection 400.3.06.A.3.b.3 and use these test results for acceptance and in calculations for the monthly plant rating. Applicable pay factors will apply and the contractor QCT test results will not be included in pay factor calculations nor in the monthly plant rating.
- Determine if the Contractor's quality control program is satisfactory and require prompt corrective action by the Contractor if specification requirements are not being met.

If the mean air voids of the pavement placed within a lot exceeds 100% of the maximum target air voids, if established and the Engineer determines that the material need not be removed and replaced, the lot may be accepted at an adjusted unit price as determined by the Engineer.

2. Obtain Uniform Compaction

For a lot to receive a pay factor of 1.00 for compaction acceptance, the air void range cannot exceed 5 percent for new construction or resurfacing projects. The range is the difference between the highest and lowest acceptance test results within the affected lot. If the air void range exceeds these tolerances, apply a Pay Factor of 95%.

The 5% reduced pay factor for the compaction range does not apply in these instances:

- The mixture is placed during the adjustment period as defined in Subsection 400.5.01.A, “Materials Produced and Placed During the Adjustment Period.”
- All air void results within a given lot are less than 7.0%.
- A lot containing two subplot or less.
- On two foot trench widening.
- For sub-surfaces mixes including 19 mm and 25 mm Superpave mixes if all air void results within a given lot are >2.5 % <8 %.

When lots are reevaluated for range penalty, as shown in Subsection 106.03, “Samples, Tests, Cited Specifications,” sampling and testing is according to GDT 73. Request for reevaluation must be made within 5 working days of notification of the lot results. The following procedures apply:

The Department will reevaluate the lot through additional testing by obtaining and testing three additional cores acquired in representative sites selected randomly throughout each sub-lot representing the high and low in-place air voids as detailed in GDT 73. The additional six cores (three cores from each sub-lot will be averaged) will replace the original five core results for range specified requirements only. The original five cores results will be reported for Pavement Mean Air Voids for the lot. This will be the final evaluation for compaction range for the lot. Lots will not be re-evaluated for range when the Pavement Mean Air Voids result in a lower than 95% pay factor. Ensure requests for reevaluation are made within 5 working days of notification of the lot results.

The Department will determine the payment for each lot by multiplying the Contract Unit Price by the adjusted pay factor shown in the Table 7 Average Air Voids Range Acceptance Schedule:

Table 7—Average Air Voids Range For Acceptance Schedule

Pay Factor	Range between High and Low Air Void Original 5 cores	Re-evaluated Range between High and Low Air Void Cores 6 New Cores obtained from High (3 cores) and Low location (3 cores)
100	≤ 5 %	≤ 4.50 %
0.95	> 5 %	> 4.50 %

C. Surface Tolerance

In this Specification, pavement courses to be overlaid with an Open-Graded Friction Course or PEM are considered surface courses. All Open-Graded Friction Courses or PEM are to be evaluated after the roadway has been opened to traffic for a minimum of 5 days and a maximum of 15 days. Asphalt paving is subject to straightedge and visual inspection and irregularity correction as shown below:

1. Visual and Straightedge Inspection

Paving is subject to visual and straightedge inspection during and after construction operations until Final Acceptance. Locate surface irregularities as follows:

- a. Keep a 10 ft (3 m) straightedge near the paving operation to measure surface irregularities on courses. Provide the straightedge and the labor for its use.
- b. Inspect the base, intermediate, and surface course surfaces with the straightedge to detect irregularities.
- c. Correct irregularities that exceed 3/16 in. in 10 ft (5 mm in 3 m) for base and intermediate courses, and 1/8 in. in 10 ft (3 mm in 3 m) for surface courses.

Mixture or operating techniques will be stopped if irregularities such as rippling, tearing, or pulling occur and the Engineer suspects a continuing equipment problem. Stop the paving operation and correct the problem. Correct surface course evaluations on individual Laser Road Profiler test sections, normally 1 mile (1 km) long.

2. Target Surface Smoothness

The Department will use the Laser Road Profiler method to conduct acceptance testing for surface course tolerance according to GDT 126. This testing will be performed only on:

- Surface courses on Projects with mainline traveled way measuring a minimum distance of 1 mile (1600 m)
- Ramps more than 0.5 mile (800 m) long

Combine partial sections measuring less than 0.5 mile (800 m) with the previous full mile for acceptance.

Achieve the smoothest possible ride during construction. Do not exceed the target Laser Road Profiler smoothness index as shown below:

Table 8— Pavement Smoothness Target Requirements

Construction Description	Smoothness Index
All Asphaltic Concrete OGFC and PEM on interstate including resurfacing and new construction. Asphaltic Concrete OGFC and PEM placed on state routes as new construction.	750
Asphaltic Concrete SMA or dense-graded surface mixtures placed directly beneath the Asphaltic Concrete OGFC or PEM on interstates. Asphaltic Concrete OGFC and PEM placed on state routes as resurfacing. All new construction on state routes with exception of OGFC and PEM as stated above.	825
All other resurfacing on state routes (excluding LARP, PR, airports, etc.)	900
All Urban new construction and resurfacing on state routes within curb and gutter sections located in posted 35 miles per hour (MPH) or less speed zones.	1175

If the target values are not achieved, immediately adjust the operations to meet the target values. Placement operations may be suspended until a remedial plan to comply with target smoothness requirements is submitted and approved by the Engineer if adjustments do not satisfy target smoothness values.

Table 9— Pavement Smoothness Corrective Work Requirement

Construction Description	Smoothness Index
All Asphaltic Concrete OGFC and PEM placed on interstate including resurfacing and new construction. Asphaltic Concrete OGFC and PEM placed on state routes as new construction.	825
Asphaltic Concrete SMA or dense-graded surface mixtures placed directly beneath the Asphaltic Concrete OGFC or PEM on interstates. Asphaltic Concrete OGFC and PEM placed on state routes as resurfacing. All new construction on state routes with exception of OGFC and PEM as stated above.	900
All other resurfacing on state routes (excluding LARP, PR, airports, etc.)	1025
All Urban new construction and resurfacing on state routes within curb and gutter sections located in posted 35 miles per hour (MPH) or less speed zones.	1250

If surface tolerance deficiencies need correction, obtain the Engineer’s approval of the methods and type mix used.

3. Bridge Approach Ride Quality

The following are subject to a ride quality test of roadway approaching each end of a bridge using the Laser Road Profiler, Rainhart Profiler or Lightweight Profiler:

- A state road with 4 lanes or more
- A 2-lane state road with a current traffic count of 2,000 vpd or more
- Locations designated on the Plans

All other bridge approaches not meeting the above criteria shall meet the 1/8 in. in 10 ft (3 mm in 3 m) straightedge requirement. When the distance between the ends of two bridges is less than 200 ft (60 m), the bridge approaches will meet the straightedge requirements.

Test ride quality as follows:

For Resurfacing Projects:

- The Department will determine a profile index value using the laser road profiler in accordance with test method GDT 126.
- The Department will determine the Half Car Simulation (HCS) IRI for each HMA asphalt 1/10th of mile (0.16 km) segments adjacent to each bridge joint for each lane. The HCS IRI will be reported in 1/20th of mile (0.08 km) segment readings in accordance with GDT 126.
 - Keep the Target profile index value under 825 mm/km and correct profile locations exceeding 900 mm/km using the Laser Road Profiler. Correct individual bumps or depression exceeding 1/8 in. in 10 ft (3 mm in 3 m) straightedge requirement as directed by the Engineer.
- Ensure Resurfacing projects meet the profile index value for the specified 1/10th mile (0.16 km) segment of roadway up to the bridge joint.

For All New Construction Projects:

- The Department will determine a profile index value according to test method GDT 78 or GDT 134.
- The Department will average the profile index value from the right and left wheelpath for each 100 ft (30 m) section for each lane.
 - Keep the profile index value under 30 in/mile (475 mm/km), correct individual bumps or depressions exceeding 0.2 in. (5 mm) from blanking band on the profilograph trace.
- Ensure New Construction projects meet the profile index value for the specified 100 ft (30 m) section of roadway up to the bridge joint.
- Schedule the ride quality testing on All New Construction projects 5 days before needed by contacting the Office of Materials and Testing. Clean and clear obstructions from the test area.

Correct the sections that do not meet the ride quality criteria of this Specification. After correction, these sections are subject to retesting with the Lightweight Profiler. The Engineer directs the type of correction method, which may include:

- Milling
- Grinding
- Removing and replacing the roadway

No additional compensation will be made.

In accordance with Section 106.3.A.3, the Contractor may request reevaluation(s) for Lightweight Profiler Test results on newly construction bridge projects, Laser Road Profiler Test results on resurfacing bridge projects and straightedge measurement(s) on either that fail to meet specified requirements. Request for reevaluation shall be made to the Engineer within 5 working days of notification of failing results. At the Engineer's approval, reevaluation of failing results using the Lightweight Profiler Test, Laser Road Profiler Test and straightedge measurement(s) shall be conducted by representatives from the Office of Materials and Testing in accordance with GDT 134.

The Department will perform ride quality testing up to two times on the bridge approaches at no cost to the Contractor. Additional testing will be charged to the Contractor in accordance with GDT 134.

4. Surface Smoothness Acceptance

When recommended by the Office of Materials and Testing, a pay reduction may be accepted in lieu of correction for roadways and bridge approaches that fail to achieve specified smoothness indexes. The Office of Materials and Testing may recommend a waiver of profile smoothness requirements when improvement over pre-construction

smoothness profile exceeds 25 percent for urban roadways, as defined in Table 9, and 15 percent for bridge approaches.

D. Reevaluation of Lots

When lots are reevaluated as shown in Subsection 106.03, “Samples, Tests, Cited Specifications,” sampling and testing is according to GDT 73. Ensure request for re-evaluation are made within 5 working days of notification of the lot results. The following procedures apply:

1. Mixture Acceptance

The Department will take the same number of new tests on cores taken at the locations where the loads sampled were placed and will use only those cores results for acceptance. If the location of the sampled loads cannot be isolated and documented to the approval of the Engineer, the lot will not be re-evaluated and the original test results will be used for acceptance. The Department will use the absolute average deviations from the job mix formula for these tests to determine acceptance based on the appropriate column in the Asphalt Cement Content and Aggregate Gradation of Asphalt Concrete Mixture Acceptance Schedule—Table 10 or 11.

2. Compaction Acceptance

The Department will reevaluate the lot through additional testing by cutting the same number of cores originally obtained and averaging these results with the results from the original density tests. The Department will use the average to determine acceptance according to the Compaction Acceptance Schedule in Subsection 400.5.01.C, “Calculate Pavement Mean Air Voids”.

Table 10—Mixture Acceptance Schedule—Surface Mixes

Mixture Characteristics	Pay Factor	Mean of the Deviations from the Job Mix Formula							
		1 Test	2 Tests	3 Tests	4 Tests	5 Tests	6 Tests	7 Tests	8 Tests
Asphalt Cement Content (Extraction, Ignition)	1.00	0.00 - 0.70	0.00 - 0.54	0.00 - 0.46	0.00 - 0.41	0.00 - 0.38	0.00 - 0.35	0.00 - 0.32	0.00 - 0.30
	0.95	0.71 - 0.80	0.55 - 0.61	0.47 - 0.52	0.42 - 0.46	0.39 - 0.43	0.36 - 0.39	0.33 - 0.36	0.31 - 0.34
	0.90	0.81 - 0.90	0.62 - 0.68	0.53 - 0.58	0.47 - 0.51	0.44 - 0.47	0.40 - 0.45	0.37 - 0.40	0.35 - 0.37
	0.80	0.91 - 1.00	0.69 - 0.75	0.59 - 0.64	0.52 - 0.56	0.48 - 0.52	0.44 - 0.47	0.41 - 0.44	0.38 - 0.41
	0.70	1.01 - 1.19	0.76 - 0.82	0.65 - 0.69	0.57 - 0.61	0.53 - 0.56	0.48 - 0.51	0.45 - 0.47	0.42 - 0.44
	0.50	1.20 - 1.40	0.83 - 0.85	0.70 - 0.72	0.62 - 0.64	0.57 - 0.59	0.52 - 0.55	0.48 - 0.51	0.45 - 0.48
3/8 in. (9.5 mm) Sieve (12.5 mm OGFC, 12.5 mm PEM, 12.5 mm Superpave)	1.00	0.00 - 9.0	0.00 - 6.6	0.00 - 5.6	0.00 - 5.0	0.00 - 4.6	0.00 - 4.2	0.00 - 3.9	0.00 - 3.6
	0.98	9.1 - 10.0	6.7 - 7.5	5.7 - 6.3	5.1 - 5.6	4.7 - 5.2	4.3 - 4.7	4.0 - 4.4	3.7 - 4.1
	0.95	10.1 - 11.9	7.6 - 8.4	6.4 - 7.0	5.7 - 6.3	5.3 - 5.8	4.8 - 5.3	4.5 - 5.0	4.2 - 4.6
	0.90	12.0 - 13.0	8.5 - 9.3	7.1 - 7.7	6.4 - 6.9	5.9 - 6.3	5.4 - 5.8	5.1 - 5.4	4.7 - 5.0
	0.85	13.1 - 14.0	9.4 - 10.2	7.8 - 8.6	7.0 - 7.6	6.4 - 6.9	5.9 - 6.3	5.5 - 5.9	5.1 - 5.5
	0.80	14.1 - 14.5	10.3 - 10.5	8.7 - 8.9	7.7 - 8.0	7.0 - 7.5	6.4 - 6.8	6.0 - 6.4	5.6 - 6.0
3/8 in. (9.5 mm) Sieve (12.5 mm SMA)	1.00	0.0 - 6.8	0.00 - 5.0	0.00 - 4.2	0.00 - 3.8	0.00 - 3.4	0.00 - 3.2	0.00 - 2.9	0.00 - 2.7
	0.98	6.9 - 7.5	5.1 - 5.6	4.3 - 4.7	3.9 - 4.2	3.5 - 3.9	3.3 - 3.5	3.0 - 3.3	2.8 - 3.1
	0.95	7.6 - 8.9	5.7 - 6.3	4.8 - 5.2	4.3 - 4.7	4.0 - 4.4	3.6 - 4.0	3.4 - 3.8	3.2 - 3.4
	0.90	9.0 - 9.8	6.4 - 7.0	5.3 - 5.8	4.8 - 5.2	4.5 - 4.8	4.1 - 4.4	3.9 - 4.1	3.5 - 3.8
	0.85	9.9 - 10.5	7.1 - 7.6	5.9 - 6.4	5.3 - 5.7	4.9 - 5.2	4.5 - 4.7	4.2 - 4.4	3.9 - 4.1
	0.80	10.6 - 10.9	7.7 - 7.9	6.5 - 6.7	5.8 - 6.0	5.3 - 5.6	4.8 - 5.1	4.5 - 4.8	4.2 - 4.5
No. 4 (4.75 mm) Sieve (9.5 mm OGFC, 9.5 mm Superpave)	1.00	0.00 - 9.0	0.00 - 6.7	0.00 - 5.7	0.00 - 5.2	0.00 - 4.8	0.00 - 4.4	0.00 - 4.1	0.00 - 3.8
	0.98	9.1 - 10.0	6.8 - 7.6	5.8 - 6.3	5.3 - 5.8	4.9 - 5.4	4.5 - 4.9	4.2 - 4.6	3.9 - 4.3
	0.95	10.1 - 11.9	7.7 - 8.5	6.4 - 6.9	5.9 - 6.4	5.5 - 5.9	5.0 - 5.4	4.7 - 5.0	4.4 - 4.7
	0.90	12.0 - 13.0	8.6 - 9.4	7.0 - 7.5	6.5 - 7.0	6.0 - 6.5	5.5 - 5.9	5.1 - 5.5	4.8 - 5.1
	0.85	13.1 - 14.0	9.5 - 10.2	7.6 - 8.0	7.1 - 7.6	6.6 - 7.0	6.0 - 6.4	5.6 - 5.9	5.2 - 5.5
	0.80	14.1 - 14.5	10.3 - 10.5	8.1 - 8.3	7.7 - 8.0	7.1 - 7.5	6.5 - 6.9	6.0 - 6.4	5.6 - 5.9

Mixture Characteristics	Pay Factor	Mean of the Deviations from the Job Mix Formula							
		1 Test	2 Tests	3 Tests	4 Tests	5 Tests	6 Tests	7 Tests	8 Tests
No. 4 (4.75 mm) Sieve (9.5 mm SMA)	1.00	0.00 - 6.8	0.00 - 5.0	0.00 - 4.3	0.00 - 3.9	0.00 - 3.6	0.00 - 3.3	0.00 - 3.1	0.00 - 2.8
	0.98	6.9 - 7.5	5.1 - 5.7	4.4 - 4.7	4.0 - 4.4	3.7 - 4.0	3.4 - 3.7	3.2 - 3.4	2.9 - 3.2
	0.95	7.6 - 8.9	5.8 - 6.4	4.8 - 5.2	4.5 - 4.8	4.1 - 4.4	3.8 - 4.0	3.5 - 3.8	3.3 - 3.5
	0.90	9.0 - 9.8	6.5 - 7.0	5.3 - 5.6	4.9 - 5.2	4.5 - 4.9	4.1 - 4.4	3.9 - 4.1	3.6 - 3.8
	0.85	9.9 - 10.5	7.1 - 7.7	5.7 - 6.0	5.3 - 5.7	5.0 - 5.2	4.3 - 4.8	4.2 - 4.4	3.9 - 4.1
	0.80	10.6 - 10.9	7.8 - 7.9	6.1 - 6.2	5.8 - 6.0	5.3 - 5.6	4.9 - 5.2	4.5 - 4.8	4.2 - 4.4
	1.00	0.00 - 7.0	0.00 - 5.6	0.00 - 4.8	0.00 - 4.3	0.00 - 4.0	0.00 - 3.6	0.00 - 3.4	0.00 - 3.2
	0.98	7.1 - 8.0	5.7 - 6.3	4.9 - 5.4	4.4 - 4.8	4.1 - 4.5	3.7 - 4.1	3.5 - 3.8	3.3 - 3.6
No. 8 (2.36 mm) Sieve (OGFC, PEM, Superpave and 4.75 mm mixes)	0.95	8.1 - 9.0	6.4 - 7.0	5.5 - 6.0	4.9 - 5.3	4.6 - 4.9	4.2 - 4.5	3.9 - 4.2	3.7 - 3.9
	0.90	9.1 - 10.9	7.1 - 7.7	6.1 - 6.6	5.4 - 5.8	5.0 - 5.4	4.6 - 4.9	4.3 - 4.6	4.0 - 4.3
	0.85	11.0 - 12.0	7.8 - 8.5	6.7 - 7.2	5.9 - 6.4	5.5 - 5.8	5.0 - 5.3	4.7 - 5.0	4.4 - 4.6
	0.75	12.1 - 12.5	8.6 - 8.8	7.3 - 7.5	6.5 - 6.8	5.9 - 6.3	5.4 - 5.7	5.1 - 5.3	4.7 - 4.9
	1.00	0.00 - 5.3	0.00 - 4.2	0.00 - 3.6	0.00 - 3.2	0.00 - 3.0	0.00 - 2.7	0.00 - 2.6	0.00 - 2.4
	0.98	5.4 - 6.0	4.3 - 4.7	3.7 - 4.0	3.3 - 3.6	3.1 - 3.4	2.8 - 3.1	2.7 - 2.9	2.5 - 2.7
	0.95	6.1 - 6.8	4.8 - 5.3	4.1 - 4.5	3.7 - 4.0	3.5 - 3.7	3.2 - 3.4	3.0 - 3.2	2.8 - 2.9
	0.90	6.9 - 8.2	5.4 - 5.8	4.6 - 5.0	4.1 - 4.5	3.8 - 4.0	3.5 - 3.7	3.3 - 3.5	3.0 - 3.2
No. 8 (2.36 mm) Sieve (12.5 mm SMA, 9.5 mm SMA)	0.85	8.3 - 9.0	5.9 - 6.4	5.1 - 5.4	4.6 - 4.8	4.1 - 4.4	3.8 - 4.0	3.6 - 3.8	3.3 - 3.4
	0.75	9.1 - 9.4	6.5 - 6.6	5.5 - 5.0	4.9 - 5.1	4.5 - 4.7	4.1 - 4.3	3.9 - 4.0	3.5 - 3.7
		No. 8 (2.36 mm) Sieve for OGFC and PEM mixes: When the mean of the deviations from the Job Mix Formula for a particular lot exceeds the tolerance for a 1.00 pay factor in the appropriate column, the lot will be paid for at 0.50 of the Contract Price.							

Table 11—Mixture Acceptance Schedule—Subsurface Mixes

Mixture Characteristics	Pay Factor	Mean of the Deviations from the Job Mix Formula							
		1 Test	2 Tests	3 Tests	4 Tests	5 Tests	6 Tests	7 Tests	8 Tests
Asphalt Cement Content (Extraction, Ignition)	1.00	0.00 - 0.80	0.00 - 0.61	0.00 - 0.52	0.00 - 0.46	0.00 - 0.43	0.00 - 0.39	0.00 - 0.36	0.00 - 0.34
	0.95	0.81 - 0.90	0.62 - 0.68	0.53 - 0.58	0.47 - 0.51	0.44 - 0.47	0.40 - 0.43	0.37 - 0.40	0.35 - 0.37
	0.90	0.91 - 1.00	0.69 - 0.75	0.59 - 0.64	0.52 - 0.56	0.48 - 0.52	0.44 - 0.47	0.41 - 0.44	0.38 - 0.41
	0.80	1.01 - 1.19	0.76 - 0.82	0.65 - 0.69	0.57 - 0.61	0.53 - 0.56	0.48 - 0.51	0.45 - 0.47	0.42 - 0.44
	0.70	1.20 - 1.40	0.83 - 0.85	0.70 - 0.72	0.62 - 0.64	0.57 - 0.59	0.52 - 0.55	0.48 - 0.51	0.45 - 0.48
	0.50	1.41 - 1.60	0.86 - 0.88	0.73 - 0.75	0.65 - 0.67	0.60 - 0.63	0.56 - 0.60	0.52 - 0.56	0.49 - 0.52
	1.00	0.00 - 12.9	0.00 - 8.1	0.00 - 6.9	0.00 - 6.1	0.00 - 5.5	0.00 - 5.0	0.00 - 4.7	0.00 - 4.4
	0.98	13.0 - 14.0	8.2 - 9.1	7.0 - 7.7	6.2 - 6.8	5.6 - 6.1	5.1 - 5.6	4.8 - 5.2	4.5 - 4.9
1/2 in. (12.5 mm) Sieve (25 mm Superpave)	0.95	14.1 - 15.0	9.2 - 10.1	7.8 - 8.5	6.9 - 7.5	6.2 - 6.7	5.7 - 6.1	5.3 - 5.7	5.0 - 5.4
	0.90	15.1 - 16.0	10.2 - 11.1	8.6 - 9.3	7.6 - 8.2	6.8 - 7.4	6.2 - 6.7	5.8 - 6.3	5.5 - 5.9
	0.85	16.1 - 17.0	11.2 - 11.5	9.4 - 9.6	8.3 - 8.6	7.5 - 7.8	6.8 - 7.0	6.4 - 6.5	6.0 - 6.1
	0.80	17.1 - 18.0	11.6 - 11.9	9.7 - 9.9	8.7 - 9.0	7.9 - 8.1	7.1 - 7.3	6.6 - 6.8	6.2 - 6.4
	1.00	0.00 - 9.7	0.00 - 6.0	0.00 - 5.2	0.00 - 4.6	0.00 - 4.1	0.00 - 3.8	0.00 - 3.5	0.00 - 3.3
	0.98	9.8 - 10.5	6.2 - 6.8	5.3 - 5.8	4.7 - 5.1	4.2 - 4.6	3.9 - 4.2	3.6 - 3.9	3.4 - 3.7
	0.95	10.6 - 11.2	6.9 - 7.8	5.9 - 6.4	5.2 - 5.6	4.7 - 5.0	4.3 - 4.6	4.0 - 4.3	3.8 - 4.0
	0.90	11.3 - 12.0	7.9 - 8.3	6.5 - 7.0	5.7 - 6.1	5.1 - 5.6	4.7 - 5.0	4.4 - 4.7	4.1 - 4.4
1/2 in. (12.5 mm) Sieve (19 mm SMA)	0.85	12.1 - 12.8	8.4 - 8.6	7.1 - 7.2	6.2 - 6.5	5.7 - 5.9	5.1 - 5.3	4.8 - 4.9	4.5 - 5.6
	0.80	12.9 - 13.5	8.7 - 8.9	7.3 - 7.4	6.6 - 6.8	6.0 - 6.1	5.4 - 5.5	5.0 - 5.1	4.7 - 4.8

Mixture Characteristics	Pay Factor	Mean of the Deviations from the Job Mix Formula							
		1 Test	2 Tests	3 Tests	4 Tests	5 Tests	6 Tests	7 Tests	8 Tests
3/8 in. (9.5 mm) Sieve (19 mm Superpave, 12.5 mm Superpave)	1.00	0.00 - 10.0	0.00 - 7.5	0.00 - 6.3	0.00 - 5.6	0.00 - 5.2	0.00 - 4.7	0.00 - 4.4	0.00 - 4.1
	0.98	10.1 - 11.9	7.6 - 8.4	6.4 - 7.0	5.7 - 6.3	5.3 - 5.8	4.8 - 5.3	4.5 - 5.0	4.2 - 4.6
	0.95	12.0 - 13.0	8.5 - 9.3	7.1 - 7.7	6.4 - 6.9	5.9 - 6.3	5.4 - 5.8	5.1 - 5.4	4.7 - 5.0
	0.90	13.1 - 14.0	9.4 - 10.2	7.8 - 8.6	7.0 - 7.6	6.4 - 6.9	5.9 - 6.3	5.5 - 5.9	5.1 - 5.5
	0.85	14.1 - 14.5	10.3 - 10.5	8.7 - 8.9	7.7 - 8.0	7.0 - 7.5	6.4 - 6.8	6.0 - 6.4	5.6 - 6.0
	0.80	14.6 - 15.0	10.6 - 10.8	9.0 - 9.2	8.1 - 8.4	7.6 - 7.8	6.9 - 7.3	6.5 - 6.8	6.1 - 6.5
No. 4 (4.75 mm) Sieve (9.5 mm Superpave)	1.00	0.00 - 10.0	0.00 - 7.6	0.00 - 6.3	0.00 - 5.8	0.00 - 5.4	0.00 - 4.9	0.00 - 4.6	0.00 - 4.3
	0.98	10.1 - 11.9	7.7 - 8.5	6.4 - 6.9	5.9 - 6.4	5.5 - 5.9	5.0 - 5.4	4.7 - 5.0	4.4 - 4.7
	0.95	12.0 - 13.0	8.6 - 9.4	7.0 - 7.5	6.5 - 7.0	6.0 - 6.5	5.5 - 5.9	5.1 - 5.5	4.8 - 5.1
	0.90	13.1 - 14.0	9.5 - 10.2	7.6 - 8.0	7.1 - 7.6	6.6 - 7.0	6.0 - 6.4	5.6 - 5.9	5.2 - 5.5
	0.85	14.1 - 14.5	10.3 - 10.5	8.1 - 8.3	7.7 - 8.0	7.1 - 7.5	6.5 - 6.9	6.0 - 6.4	5.6 - 5.9
	0.80	14.6 - 15.0	10.6 - 10.8	8.4 - 8.6	8.1 - 8.4	7.6 - 8.0	7.0 - 7.4	6.5 - 6.8	6.0 - 6.3
No. 8 (2.36 mm) Sieve (All mixes except SMA)	1.00	0.00 - 8.0	0.00 - 6.3	0.00 - 5.4	0.00 - 4.8	0.00 - 4.5	0.00 - 4.1	0.00 - 3.8	0.00 - 3.6
	0.98	8.1 - 9.0	6.4 - 7.0	5.5 - 6.0	4.9 - 5.3	4.6 - 4.9	4.2 - 4.5	3.9 - 4.2	3.7 - 3.9
	0.95	9.1 - 10.0	7.1 - 7.7	6.1 - 6.6	5.4 - 5.8	5.0 - 5.4	4.6 - 4.9	4.3 - 4.6	4.0 - 4.3
	0.90	10.1 - 11.9	7.8 - 8.5	6.7 - 7.2	5.9 - 6.4	5.5 - 5.8	5.0 - 5.3	4.7 - 5.0	4.4 - 4.6
	0.85	12.0 - 13.0	8.6 - 8.8	7.3 - 7.5	6.5 - 6.8	5.9 - 6.3	5.4 - 5.7	5.1 - 5.3	4.7 - 4.9
	0.75	13.1 - 14.0	8.9 - 9.1	7.6 - 7.8	6.9 - 7.2	6.4 - 6.6	5.8 - 6.1	5.4 - 5.7	5.0 - 5.3
No. 8 (2.36 mm) Sieve (19 mm SMA)	1.00	0.00 - 6.0	0.00 - 4.7	0.00 - 4.1	0.00 - 3.6	0.00 - 3.4	0.00 - 3.1	0.00 - 2.9	0.00 - 2.4
	0.98	6.1 - 6.8	4.8 - 5.2	4.2 - 4.5	3.7 - 4.0	3.5 - 3.7	3.2 - 3.4	3.0 - 3.2	2.8 - 2.9
	0.95	6.9 - 7.5	5.3 - 5.8	4.6 - 5.0	4.1 - 4.4	3.8 - 4.0	3.5 - 3.7	3.3 - 3.5	3.0 - 3.2
	0.90	7.6 - 8.9	5.9 - 6.4	5.1 - 5.4	4.5 - 4.8	4.1 - 4.4	3.8 - 4.0	3.6 - 3.8	3.3 - 3.5

Mixture Characteristics	Pay Factor	Mean of the Deviations from the Job Mix Formula							
		1 Test	2 Tests	3 Tests	4 Tests	5 Tests	6 Tests	7 Tests	8 Tests
	0.85	9.0 - 9.8	6.5 - 6.6	5.5 - 5.6	4.9 - 5.1	4.5 - 4.7	4.1 - 4.3	3.9 - 4.0	3.6 - 3.7
	0.75	9.9 - 10.5	6.7 - 6.8	5.7 - 5.9	5.2 - 5.4	4.8 - 5.0	4.4 - 4.6	4.1 - 4.3	3.8 - 4.0

E. Segregated Mixture

Prevent mixture placement yielding a segregated mat by following production, storage, loading, placing, and handling procedures. Ensure needed plant modifications and provide necessary auxiliary equipment. (See Subsection 400.1.01, "Definitions.")

If the mixture is segregated in the finished mat, the Department will take actions based on the degree of segregation. The actions are described below.

1. Unquestionably Unacceptable Segregation

When the Engineer determines the segregation in the finished mat is unquestionably unacceptable, follow these measures:

- a. Suspend Work and require the Contractor to take positive corrective action. The Department will evaluate the segregated areas to determine the extent of the corrective work to the in-place mat as follows:
 - Perform extraction and gradation analysis by taking 6 in (150 mm) cores from typical, visually unacceptable segregated areas.
 - Determine the corrective work according to Subsection 400.3.06.E.3.
- b. Require the Contractor to submit a written plan of measures and actions to prevent further segregation. Work will not continue until the plan is submitted to and approved by the Department.
- c. When work resumes, place a test section not to exceed 500 tons (500 Mg) of the affected mixture for the Department to evaluate. If a few loads show that corrective actions were not adequate, follow the measures above beginning with step 1.a. above. If the problem is solved, Work may continue.

2. Unacceptable Segregation Suspected

When the Engineer observes segregation in the finished mat and the work may be unacceptable, follow these measures:

- a. Allow work to continue at Contractor's risk.
- b. Require Contractor to immediately and continually adjust operation until the visually apparent segregated areas are eliminated from the finished mat. The Department will immediately investigate to determine the severity of the apparent segregation as follows:
 - Take 6 in (150 mm) cores from typical areas of suspect segregation.
 - Test the cores for compliance with the mixture control tolerances in Section 828.

When these tolerances are exceeded, suspend work for corrective action as outlined in Subsection 400.3.06.E.3.

3. Corrective Work

- a. Remove and replace (at the Contractor's expense) any segregated area where the gradation on the control sieves is found to vary 10 percent or more from the approved job mix formula, the asphalt cement varies 1.0% or more from the approved job mix formula, or if in-place air voids exceed 13.5% based on GDT 39. The control sieves for each mix type are shown in Subsection 400.5.01.B "Determine Lot Acceptance."
- b. Subsurface mixes. For subsurface mixes, limit removal and replacement to the full lane width and no less than 10 ft. (3 m) long and as approved by the Engineer.
- c. Surface Mixes. For surface mixes, ensure that removal and replacement is not less than the full width of the affected lane and no less than the length of the affected areas as determined by the Engineer.

Surface tolerance requirements apply to the corrected areas for both subsurface and surface mixes.

400.3.07 Contractor Warranty and Maintenance

A. Contractor's Record

Maintain a dated, written record of the most recent plant calibration. Keep this record available for the Engineer's inspection at all times. Maintain records in the form of:

- Graphs
- Tables

- Charts
- Mechanically prepared data

400.4 Measurement

Thickness and spread rate tolerances for the various mixtures are specified in Subsection 400.4.A.2.b, Table 112, Thickness and Spread Rate Tolerance at Any Given Location. These tolerances are applied as outlined below:

A. Hot Mix Asphaltic Concrete Paid for by Weight

1. Plans Designate a Spread Rate

- Thickness Determinations. Thickness determinations are not required when the Plans designate a spread rate per square yard (meter).

If the spread rate exceeds the upper limits outlined in the Subsection 400.4.A.2.b, Table 12, “Thickness and Spread Rate Tolerance at Any Given Location”, the mix in excess will not be paid for.

If the rate of spread is less than the lower limit, correct the deficient course by overlaying the entire lot.

The mixture used for correcting deficient areas is paid for at the Contract Unit Price of the course being corrected and is subject to the Mixture Acceptance Schedule—Table 10 or 11.

- Recalculate the Total Spread Rate. After the deficient hot mix course has been corrected, the total spread rate for that lot is recalculated, and mix in excess of the upper tolerance limit as outlined in the Subsection 400.4.A.2.b, Table 12, “Thickness and Spread Rate Tolerance at Any Given Location” is not paid for.

The quantity of material placed on irregular areas such as driveways, turnouts, intersections, feather edge section, etc., is deducted from the final spread determination for each lot.

2. Plans Designate Thickness

If the average thickness exceeds the tolerances specified in the Subsection 400.4.A.2.b, Table 112, “Thickness and Spread Rate Tolerance at Any Given Location”, the Engineer shall take cores to determine the area of excess thickness. Excess quantity will not be paid for.

If the average thickness is deficient by more than the tolerances specified in the Thickness and Spread Rate Tolerance at Any Given Location table below, the Engineer shall take additional cores to determine the area of deficient thickness. Correct areas with thickness deficiencies as follows:

- Overlay the deficient area with the same mixture type being corrected or with an approved surface mixture. The overlay shall extend for a minimum of 300 ft (90 m) for the full width of the course.
- Ensure that the corrected surface course complies with Subsection 400.3.06.C.1, “Visual and Straightedge Inspection.” The mixture required to correct a deficient area is paid for at the Contract Unit Price of the course being corrected.

The mixture is subject to the Mixture Acceptance Schedule—Table 910 or 11 . The quantity of the additional mixture shall not exceed the required calculated quantity used to increase the average thickness of the overlaid section to the maximum tolerance allowed under the following table.

Table 12—Thickness and Spread Rate Tolerance at Any Given Location

Course	Thickness Specified	Spread Rate Specified
Asphaltic concrete base course	± 0.5 in (±13 mm)	+40 lbs, -50 lbs (+20 kg, -30 kg)
Intermediate and/or wearing course	± 0.25 in (± 6 mm)	+20 lbs, -25 lbs (+10 kg, -15 kg)
Overall of any combination of 1 and 2	± 0.5 in (±13 mm)	+40 lbs, -50 lbs (+20 kg, -30 kg)

Note 1: For asphaltic concrete 9.5 mm OGFC and 12.5 mm OGFC, control the spread rate per lot within 5 lbs/yd² (3 kg/m²) of the designated spread rate. For asphaltic concrete 12.5 mm PEM, control the spread rate per lot within 10 lbs/yd² (6 kg/m²) of the designated spread rate.

Note 2: Thickness and spread rate tolerances are provided to allow normal variations within a given lot. Do not continuously operate at a thickness of spread rate not specified.

When the Plans specify a thickness, the Engineer may take as many cores as necessary to determine the average thickness of the intermediate or surface course. The Engineer shall take a minimum of one core per 1,000 ft (300 m) per two lanes of roadway. Thickness will be determined by average measurements of each core according to GDT 42.

If the average exceeds the tolerances specified in the Subsection 400.4.A.2.b, Table 112, “Thickness and Spread Rate Tolerance at Any Given Location”, additional cores will be taken to determine the area of excess thickness and excess tonnage will not be paid for.

B. Hot Mix Asphaltic Concrete Paid for by Square Yard (Meter)

1. The thickness of the base course or the intermediate or surface course will be determined by the Department by cutting cores and the thickness will be determined by averaging the measurements of each core.
2. If any measurement is deficient in thickness more than the tolerances given in the table above, additional cores will be taken by the Department to determine the area of thickness deficiency. Correct thickness deficiency areas as follows:
 - a. Overlay the deficient area with the same type mixtures being corrected or with surface mixture. Extend the overlay at least 300 ft (90 m) for the full width of the course.
 - b. Ensure the corrected surface course complies with Subsection 400.3.06.C.1, Visual and Straightedge Inspection” .
 - c. The mixture is subject to the Mixture Acceptance Schedule—Table 10 or 11.
3. No extra payment is made for mixtures used for correction.
4. No extra payment is made for thickness in excess of that specified.

NOTE: Thickness tolerances are provided to allow normal variations within a given lot. Do not continuously operate at a thickness not specified.

C. Asphaltic Concrete

Hot mix asphaltic concrete, complete in place and accepted, is measured in tons (megagrams) or square yards (meters) as indicated in the Proposal. If payment is by the ton (megagram), the actual weight is determined by weighing each loaded vehicle on the required motor truck scale as the material is hauled to the roadway, or by using recorded weights if a digital recording device is used.

The weight measured includes all materials. No deductions are made for the weight of the individual ingredients. The actual weight is the pay weight except when the aggregates used have a combined bulk specific gravity greater than 2.75. In this case the pay weight is determined according to the following formula:

$$T1 = T \times \left\{ \% AC + \frac{\left(\frac{\% \text{ Aggregate} \times 2.75}{\text{combined bulk Specific Gravity}} \right) + \% Y}{100} \right\}$$

Where:

T1	Pay weight, tonnage (Mg)
T=	Actual weight
% AC=	Percent asphalt cement by weight of total mixture
% Aggregate =	Percent aggregate by weight of total mixture
Combined Bulk Sp. Gr.=	Calculated combined bulk specific gravity of various mineral aggregates used in the mixture

% Y=	Percent hydrated lime by weight of mineral aggregate
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D. Bituminous Material

Bituminous material is not measured for separate payment.

E. Hydrated Lime

When hydrated lime is used as an anti-stripping additive, it is not measured for separate payment.

F. Field Laboratory

The field laboratory required in this Specification is not measured for separate payment.

G. Asphaltic Concrete Leveling

Payment of hot mix asphaltic concrete leveling, regardless of the type mix, is full compensation for furnishing materials, bituminous materials, and hydrated lime (when required) for patching and repair of minor defects, surface preparation, cleaning, hauling, mixing, spreading, and rolling.

Mixture for leveling courses is subject to the acceptance schedule as stated in Subsection 400.3.06.A and Subsection 400.3.06.B.

H. Asphaltic Concrete Patching

Hot mix asphaltic concrete patching, regardless of the type mix, is paid for at the Contract Unit Price per ton (Megagram), complete in place and accepted. Payment is full compensation for:

- Furnishing materials such as bituminous material and hydrated lime (when required)
- Preparing surface to be patched
- Cutting areas to be patched, trimmed, and cleaned
- Hauling, mixing, placing, and compacting the materials

400.4.01 Limits

When the asphaltic concrete is paid for by the square yard (meter) and multiple lifts are used, the number and thickness of the lifts are subject to the Engineer’s approval and are used to prorate the pay factor for the affected roadway section.

400.5 Payment

When materials or construction are not within the tolerances in this Specification, the Contract Price will be adjusted according to Subsection 106.03, “Samples, Tests, Cited Specifications” and Subsection 400.3.06, “Quality Acceptance.”

Hot mix asphaltic concrete of the various types are paid for at the Contract Unit Price per ton (megagram) or per square yard (meter). Payment is full compensation for furnishing and placing materials including asphalt cement, hydrated lime when required, approved additives, and for cleaning and repairing, preparing surfaces, hauling, mixing, spreading, rolling, and performing other operations to complete the Contract Item.

Payment will be made under:

Item No. 400	Asphaltic concrete <u>type</u> Superpave, <u>group-blend</u> , Including polymer-modified bituminous materials and hydrated lime	Per ton (megagram)
Item No. 400	Asphaltic concrete <u>type</u> , Superpave, <u>group-blend</u> , including bituminous materials and hydrated lime	Per ton (megagram)
Item No. 400	Asphaltic concrete <u>type</u> Superpave, <u>group-blend</u> , Including bituminous materials, Gilsonite modifier, and hydrated lime	Per ton (megagram)

Item No. 400	_____ inches asphaltic concrete, <u>type</u> Superpave, <u>group-blend</u> including bituminous materials, Gilsonite modifier and hydrated lime	Per square yard (meter)
Item No. 400	Asphaltic concrete <u>type</u> Stone Matrix Asphalt, <u>group-blend</u> , including polymer-	Per ton (megagram)

	modified bituminous materials and hydrated lime	
Item No. 400	Asphaltic concrete <u>type</u> OGFC, <u>group 2</u> only, including bituminous materials and hydrated lime	Per ton (megagram)
Item No. 400	Asphaltic concrete <u>type</u> OGFC, <u>group 2</u> only, including polymer-modified bituminous materials and hydrated lime	Per ton (megagram)
Item No. 400	Asphaltic concrete <u>type</u> Porous European Mix, <u>group 2</u> only, including polymer-modified bituminous materials and hydrated lime	Per ton (megagram)

400.5.01 Adjustments

A. Materials Produced and Placed During the Adjustment Period

An adjustment period is allowed at the start of mixing operations for each type of mix placed on the Contract. Asphaltic Concrete OGFC or PEM shall be granted an adjustment period for the first 500 tons (500 Mg) produced for the Contract. A new adjustment period shall not be granted for a change of producer, mix design or asphalt plant location. The adjustment period is provided to adjust or correct the mix and to establish the construction procedures and sequence of operations.

The adjustment period consists of the tons (megagrams) of the affected mix produced and placed on the first day of operation. If this quantity is less than 500 tons (500 Mg), the Engineer may combine the tons (megagrams) produced and placed on the first day of operation with the tons (megagrams) produced and placed on the next production day of the affected mix for the adjustment period.

The material produced and placed during the mixture adjustment period is one lot. If the mix is adjusted during this period, a new lot may be necessary, but a new adjustment period will not be permitted.

This material shall be paid for at 100 percent of the Contract Unit Price provided it meets the minimum requirements for a 1.00 pay factor for asphalt cement content and a 0.90 pay factor for gradation in the Mixture Acceptance Schedule—Table 10 or 11 .

If the material placed during the adjustment period fails to meet the above requirements, it will be paid for using the applicable acceptance schedule. However, when mixture used for leveling at a spread rate of 90 lbs/yd² (50 kg/m²) or less is also used for the surface mix at a spread rate greater than 90 lbs/yd² (50 kg/m²), an additional adjustment period will be allowed for compaction only. This material will be paid for at a 1.00 pay factor provided it:

- Meets the minimum requirements for a 1.00 pay factor in the Mixture Acceptance Schedule—Table 10 or 11 for both asphalt content and gradation.
- Meets the minimum requirements for a 0.90 pay factor in Table 13 of Subsection 400.5.01C, “Calculate Mean Pavement Air Voids.

Mixture which does not meet these requirements shall be paid for using the applicable acceptance schedule.

B. Determine Lot Acceptance

Pay factor adjustments are based on control sieves and asphalt cement content. The control sieves used in the mixture acceptance schedule for the various types of mix are indicated below:

Control Sieves Used in the Mixture Acceptance Schedule	
Asphaltic concrete 25 mm Superpave	1/2 in., No. 8 (12.5 mm, 2.36 mm) sieves and asphalt cement
Asphaltic concrete 19 mm SMA	1/2 in., No. 8 (12.5 mm, 2.36 mm) sieves and asphalt cement
Asphaltic concrete 19 mm Superpave	3/8 in., No. 8 (9.5 mm, 2.36 mm) sieves and asphalt cement
Asphaltic concrete 12.5 mm Superpave	3/8 in., No. 8 (9.5 mm, 2.36 mm) sieves and asphalt cement
Asphaltic concrete 12.5 mm SMA	3/8 in., No. 8 (9.5 mm, 2.36 mm) sieves and asphalt cement
Asphaltic concrete 12.5 mm PEM	3/8 in., No. 8 (9.5 mm, 2.36 mm) sieves and asphalt cement

Control Sieves Used in the Mixture Acceptance Schedule	
Asphaltic concrete 12.5 mm OGFC	3/8 in., No. 8 (9.5 mm, 2.36 mm) sieves and asphalt cement
Asphaltic concrete 9.5 mm Superpave	No. 4, No. 8 (4.75 mm, 2.36 mm) sieves and asphalt cement
Asphaltic concrete 9.5 mm SMA	No. 4, No. 8 (4.75 mm, 2.36 mm) sieves and asphalt cement
Asphaltic concrete 9.5 mm OGFC	No. 4, No. 8 (4.75 mm, 2.36 mm) sieves and asphalt cement
Asphaltic concrete 4.75 mm Mix	No. 8 (2.36 mm) sieve and asphalt cement

For projects which do not have milling quantities established as a Pay Item, the Department will pay for 12.5 mm OGFC and PEM placed on ramps and end of project transitions under the appropriate mixture pay item, but the mix shall be subject to the same gradation and control sieve requirements as asphaltic concrete 9.5 mm OGFC. Add polymer-modified bituminous material, hydrated lime, and stabilizing fiber to this mix.

The Department will perform the following tasks:

1. Using the Mixture Acceptance Schedule—Table 10 or 11, determine the mean of the deviations from the job mix formula per test results per lot.
2. Determine this mean by averaging the actual numeric value of the individual deviations from the job mix formula; disregard whether the deviations are positive or negative amounts.
3. Use the Asphalt Cement Content and Aggregate Gradation of Asphalt Concrete Mixture Acceptance Schedule—Table 10 to determine acceptance of surface mixes and the Mixture Acceptance Schedule—Table 11 to determine acceptance of subsurface mixes.

On Contracts involving 1,000 tons (1000 Mg) or less of asphaltic concrete, the mixture is accepted for 100 percent payment of the asphaltic concrete Unit Price provided it meets the following:

1. Minimum requirements for a 1.00 pay factor for asphalt cement content and a 0.90 pay factor for gradation in the applicable Mixture Acceptance Schedule—Table 10 or 11.
2. Minimum requirements for a 0.90 pay factor in Table 13 of Subsection 400.5.01C, “Calculate Pavement Mean Air Voids.”

If the material placed on Contracts involving 1,000 tons (1000 Mg) or less of asphaltic concrete does not meet the above requirements, the material will be paid for using the applicable acceptance schedule.

C. Calculate Pavement Mean Air Voids

The Department will determine the percent of maximum air voids for each lot by dividing the pavement mean air voids by the maximum pavement mean air voids acceptable.

The Department will determine the payment for each lot by multiplying the Contract Unit Price by the adjusted pay factor shown in the following Air Voids Acceptance Schedule:

Table 13 - Air Voids Acceptance Schedule

Pay Factor	Percent of Maximum Air Voids (Lot Average of Tests)	Percent of Maximum Air Voids (Lot Average all Tests) (for Reevaluations)
1.00	≤100	≤100
0.97	100.1 — 105	100.1 — 104
0.95	105.1 — 112	104.1 — 109
0.90	112.1 — 124	109.1 — 118
0.80	124.1 — 149	118.1 — 136
0.70	149.1 — 172	136.1 — 153
0.50	172.1 — 191	153.1 — 166

When recommended by the Office of Materials and Testing, Lots receiving less than 0.5 pay factor shall be removed and replaced at the Contractor's expense.

When the range tolerance is exceeded, the Department will apply a pay factor of 0.95 as described in Subsection 400.3.06.B.2.

D. Asphaltic Concrete For Temporary Detours

Hot mix asphaltic concrete placed on temporary detours not to remain in place as part of the permanent pavement does not require hydrated lime. Hot mix used for this purpose is paid for at an adjusted Contract Price. Ensure the payment for this item covers all cost of construction, maintenance and removal of all temporary mix. Ensure hot mix asphaltic concrete placed as temporary mix meets requirements established in Subsection 400.3.05.F.

Where the Contract Price of the asphaltic concrete for permanent pavement is let by the ton (megagram), the Contract Price for the asphaltic concrete placed on temporary detours is adjusted by subtracting \$0.75/ton (\$0.85/mg) of mix used.

Where the Contract price of the mix in the permanent pavement is based on the square yard (meter), obtain the adjusted price for the same mix used on the temporary detour by subtracting \$0.04/yd² (\$0.05/ m²) per 1-in (25-mm) plan depth.

Further price adjustments required in Subsection 400.3.06, "Quality Acceptance," which are based on the appropriate adjusted Contract Price for mix used in the temporary detour work shall apply should temporary mix be left in place. Ensure hot mix asphalt produced as temporary mix containing no hydrated lime is removed and replaced with permanent mix containing hydrated lime.

E. Determine Lot Payment

Determine the lot payment as follows:

1. When one of the pay factors for a specific acceptance lot is less than 1.0, determine the payment for the lot by multiplying the Contract Unit Price by the adjusted pay factor.
2. When two or more pay factors for a specific acceptance lot are less than 1.0, determine the adjusted payment by multiplying the Contract Unit Price by the lowest pay factor.

If the mean of the deviations from the job mix formula of the tests for a sieve or asphalt cement content exceeds the tolerances established in the Mixture Acceptance Schedule—Table 10 or 11 and if the Engineer determines that the material need not be removed and replaced, the lot may be accepted at an adjusted unit price as determined by the Engineer. If the pavement mean air voids exceed the tolerances established in the Air Voids Acceptance Schedule – Table 13, remove and replace the materials at the Contractor's expense.

If the Engineer determines the material is not acceptable to leave in place, remove and replace the materials at the Contractor's expense.

Section 403—Hot In-Place Recycled Asphaltic Concrete

Delete Section 403 and substitute the following:

403.1 Description

This Section covers the hot in-place recycling of the existing surface in a continuous multi-step process which includes:

- Softening the existing surface with heat
- Hot milling to obtain the depth shown in the plan typical section or stated in the contract general notes
- Applying a tack coat
- Applying a rejuvenating agent
- Adding plant produced asphaltic concrete and virgin aggregate, if needed, prior to remixing
- Thoroughly remixing, leveling, and relaying the recycled mixture

403.1.01 Definitions

General Provisions 101 through 150.

403.1.02 Related References

A. Standard Specifications

Section 106

Section 109

Section 400

Section 402

Section 800

Section 824

B. Referenced Documents

AASHTO T-49

AASHTO T 245

AASHTO T-209

AASHTO T 312

AASHTO T 315

ASTM D92

ASTM D2170

ASTM D2872

ASTM D4124

GDT 38

GDT 42

GDT 66

GDT 83

GDT 115

GDT 119

Section 403—Hot In-Place Recycled Asphaltic Concrete

GDT 125

GDT 126

GSP 15

403.1.03 Submittals

Submit the proposed mix design for approval. Ensure that sufficient roadway cores are obtained to provide a representative sample of the in-place material for the mix design. Additional mix design(s) may be required for areas where in-place materials vary significantly. As a minimum, the mix design shall include the following:

- The proportional blend of in-place materials and rejuvenating agent
- The proportional percentage of virgin aggregate and plant-produced hot mix asphalt, if required
- The sources of all materials to be used in the mixture
- The theoretical maximum specific gravity of the final mixture determined by AASHTO T-209
- The air void volume of the mixture after compacting for 65 gyrations with a Superpave gyratory compactor according to AASHTO T 315 or 50 blows using the Marshall Mix Design method.

Use an approved, qualified laboratory to perform the mixture design analysis. Ensure the final design mixture has an air void volume within 3.5-5%.

Submit to the Office of Materials and Testing (OMAT) representative batched samples of each ingredient to be used in the final in-place mixture for design verification and additional testing as needed. The Department will perform testing for moisture damage susceptibility for using GDT 66 and rutting susceptibility using GDT 115. Adjust mixture proportions as needed to ensure the final mixture mix design meets the following requirements:

- Average rut depth not to exceed 0.3 in (7 mm) when tested using GDT 115.
- Submit samples of the composite blend for Abrasion Recovery in accordance with GDT119 and Section 403.3.06
- Minimum tensile splitting ratio of 80% and minimum individual strength results of 60 psi (415 kPa) when tested using GDT 66.

EXCEPTION: A tensile splitting ratio of no less than 70% is acceptable so long as all individual test values exceed 100 psi (690 kPa).

Allow the Department two weeks to verify the mix design after receiving the proposed mix design and material. Do not begin recycling operations until the Department has approved the design and accepted the mixture.

403.2 Materials

The materials to be used and their specifications are listed below:

A. Aggregate

Add virgin aggregate, if required, which is from an approved source and which meets requirements of Section 800. Use the stone size and spread rate specified in the plans. Additional virgin aggregate from approved sources may be added based on the mixture design analysis at no additional cost to the Department.

B. Plant-Produced Hot Mix Asphaltic Concrete

Add the type and amount of plant-produced asphaltic concrete, if required, as specified in the plans. Additional asphaltic concrete may be added based on the mixture design analysis at no additional cost to the Department. Ensure the hot mix asphaltic concrete is produced according to Section 400 and Section 402.

C. Asphalt Cement Rejuvenating Agent

Obtain approval by the Office of Materials and Testing for the source, amount, compatibility and type of rejuvenating agent to be used. The rejuvenating agent must comply with current standards established by the Environmental Protection Agency. The Department reserves the right to change, without a change in the contract unit price, the agent and amount being used in the mixture if it is determined by the Engineer that the rejuvenating agent is not performing satisfactorily.

Section 403—Hot In-Place Recycled Asphaltic Concrete

D. Bituminous Tack Coat

Use a cationic asphalt emulsion for the bituminous tack coat that meets Section 824. Apply the tack coat with a system equipped with positive stop/start capabilities that will prevent tack puddles and which will uniformly distribute the tack across the full width of the surface being recycled. Apply tack after the existing surface has been heated, milled, and removed from the roadway and prior to replacing the material onto the roadway.

E. Asphalt Modifier

Provide asphalt modifier as specified in the Plans. It shall be added at a dosage rate that will yield at least 3% solid polymer by weight of the asphalt cement of the in-place material. Asphalt modifiers shall be approved by the Office of Materials and Testing prior to use in the work. The Department reserves the right to change the type modifier and amount to be used, without a change in the contract unit price, if the Engineer determines that the asphalt modifier is not performing satisfactorily.

403.2.01 Delivery, Storage, and Handling

A. Aggregate Storage

Store or stockpile mineral aggregates in a manner that will prevent segregation, mixing of the various sizes, and contamination with foreign materials.

B. Storage of Bituminous Material

Always keep clean all equipment used to store and handle bituminous material and operate it in such a manner to prevent contamination with foreign matter.

403.3 Construction Requirements

403.3.01 Personnel

General Provisions 101 through 150.

403.3.02 Equipment

The Engineer shall approve all equipment, tools, and machines used to perform this work. Do not attempt work with malfunctioning equipment. The Engineer may stop the work if equipment and tools are not sufficient to place the materials satisfactorily.

A. Heating and Milling Units

Ensure the heating unit meets the following requirements:

- Capable of heating the asphaltic concrete pavement to a temperature high enough to remove excess moisture and allow hot milling of the material to the designated plan depth without breaking aggregate particles
- Controls the heating process to prevent charring the existing surface, avoid producing undesirable pollutants, and prevent differential softening of the pavement
- Ensure that heating units do not create excessive smoke that may impede traffic
- Confine the heat application under a shielded, or enclosed, hood
- Ensure that the temperature of the heated surface never exceeds 375 ° F (190 °C)
- If degradation of the in-place asphaltic concrete aggregate is observed, add additional pre-heaters and/or reduce the speed of operation.

Make all efforts to protect adjacent landscape from heat damage. Rebuild, repair, restore, and make good all injuries or damages to adjacent landscape, at the Contractor's expense. Equip the unit which contains milling heads with longitudinal grade controls as described in Subsectin 403.3.02.C which will consistently control the depth of the milling operation. Milling heads shall remove the heated existing pavement to the depth specified in the Plans for the full transverse width even if additional virgin aggregate or asphaltic concrete mixture is added at no cost to the Department.

Use a portable milling unit to remove heated material from around utility structures to the full plan depth just prior to placement of the recycled material. Do not attempt to remove heated material from utility structures with hand tools only and do not damage the structures. Repair any damage to structures at no cost to the Department.

Section 403—Hot In-Place Recycled Asphaltic Concrete

B. Blending Unit

Provide a blending unit which meets the following requirements:

- Capable of blending the removed material and rejuvenating agent (as well as virgin aggregate, asphalt modifier, and plant-produced hot mix asphaltic concrete, if required) into a homogeneous mixture
- Synchronizes application of all materials based on the volume of material being recycled to provide a proportional application at the predetermined application rate
- Ensure that adequate temperature for mixing the rejuvenation agent, any admixture and recycled material is achieved between $240\text{ }^{\circ}\text{F} \pm 20\text{ }^{\circ}\text{F}$.

Add the rejuvenator after milling has taken place and before or during the blending process with a positive start/stop mechanism that is automatically controlled by the volume of recycled material to be rejuvenated. Do not add rejuvenator based on linear distance travelled.

Add asphalt modifier, if required, at locations specified in the Plans or directed by the Engineer. Add modifiers during the blending process through a distribution system that will uniformly control the rate of application based on the volume of material being recycled and which contains a measuring system to verify the dosage rate.

C. Screed

Ensure the screed meets the following requirements:

- Capable of collecting and distributing the recycled mixture over variable widths for the entire width being processed
- Capable of controlling transverse cross-slope as directed by the Engineer
- Provides a uniform cross-section without streaks or blemishes
- Controls longitudinal grade electronically in conjunction with a mobile reference or by a non-contacting laser or sonar type ski with at least four referencing stations mounted at a minimum length of 24 feet (7.2 m)

D. Auxilliary Equipment

Provide suitable surface cleaning equipment, hand tools, rollers, and other support equipment necessary to perform the work. Ensure all other equipment meets requirements of Section 400.

403.3.03 Preparation

General Provisions 101 through 150.

403.3.04 Fabrication

General Provisions 101 through 150.

403.3.05 Construction

A. Surface Preparation

Thoroughly clean the surface to be recycled of all dirt, vegetation, and other objectionable materials immediately prior to the affected area being recycled. Remove all metal raised pavement markers and thermoplastic paint markings prior to recycling.

B. Heat, Remove, and Blend Materials

Evenly heat the pavement at full lane width plus a minimum 3 in (75 mm) overlap onto adjacent pavement materials. Control the heating to ensure uniform penetration without differential softening of the surface, and so that the heated material has a temperature in the range of $240 \pm 20\text{ }^{\circ}\text{F}$ ($115 \pm 11\text{ }^{\circ}\text{C}$) measured immediately behind the heating unit. Ensure heated material temperatures do not vary greater than $20\text{ }^{\circ}\text{F}$ ($11\text{ }^{\circ}\text{C}$) when taken transversely across the mat behind the screed. If virgin aggregate is added, distribute the aggregate across the entire width being recycled prior to the last heat application.

Hot mill and rework the pavement to the width and depth shown in the plan typical section. Control the width of each pass to provide proper placement of longitudinal joints. Control the depth of loosened pavement to within 1/4 in (6 mm) of the depth specified. Ensure the milled material is heated sufficiently so that it is free of lumps. Milled particles shall not be greater than 1-1/2 in (40 mm) in size. Accomplish the recycling by using milling heads capable of gathering the loose material and conveying it to a mixing chamber. The mixing chamber should blend the material uniformly and create a windrow with the final mix. Do not use scrappers, scarifiers, or any mechanical means of removing the softened pavement other than milling heads.

Section 403—Hot In-Place Recycled Asphaltic Concrete

Ensure the final blended mix in the windrow is uniform. All aggregate shall be consistently coated. There shall be no evidence of broken or fractured aggregate in the windrowed material. Inconsistency and or non-uniformity of the windrowed material prior to placement will result in the immediate cessation of recycling until a plan of corrective action is approved by the Engineer. After modifications to the equipment or adjustment to the additives proportions have been made and approved, the Contractor should be allowed to resume work in a 500 ft (152 m) test section to be evaluated by the Engineer prior to continuing recycling

Blend the removed material with a rejuvenating agent (and virgin aggregate, asphalt modifier, or plant-produced hot mix asphaltic concrete, if needed) to produce a homogeneous mixture. Control the rate of application of the rejuvenator to ensure compliance with the mix design and Dynamic Shear Rheometer (DSR) values specified in Subsection 403.3.06.A. Apply other materials as specified in the contract or as determined by the mix design analysis.

C. Tack Coat

Apply tack coat uniformly over the milled area prior to placement of the blended materials. Control the application rate in accordance with Section 413. At any time during the recycling process it is observed that an adequate bond is not being achieved, three six-inch (150mm) cores may be obtained for testing. These cores will be evaluated for adequate bond strength using NCAT's bond shear device in conjunction with the Marshall Apparatus. A minimum shear strength of 50 psi shall be required in accordance with GDT-57.

D. Application

Control placement of the mixture to produce a surface true to line, grade, and cross-slope with a uniform surface texture free of segregation, lumps, or other unacceptable streaks or blemishes as determined by the Engineer. Ensure the mixture meets the acceptance requirements for mixture quality, compaction, smoothness, and thickness as specified in Subsection 403.3.06.

E. Overlay

Prior to overlay, allow the hot-in-place recycled material to cure for a minimum of seven (7) days or as directed by the Engineer. Overlay the recycled mixture, if required by the contract, by producing and placing a mixture that meets requirements of Section 400 and Section 402. Smoothness requirements for the hot in-place recycled mixture do not apply if the mixture is overlaid.

403.3.06 Quality Acceptance

A. Mixture

Base acceptance of the materials used in the work on Section 106 and Section 400 except that pay factors for gradation and asphalt content will not apply. Take a minimum of one sample of mixture for each 4500 Sq/yd recycled per day of operation to determine quality acceptance of the mixture.

Take samples directly behind the paver according to GSP 15 at the location determined by the Engineer. Perform extraction and gradation testing according to GDT 83 and GDT 38 or other suitable method approved by the Office of Materials and Testing. Determine the laboratory density, stability and flow of the mixture using the 50 blow Marshall procedure in AASHTO T-245. Report the test results daily to the District Laboratory and Bituminous Technical Services Engineer. Test results failing to meet specified tolerances are to be reported immediately.

Recover the extracted asphalt cement using GDT 119 and test for dynamic shear according to AASHTO T312, Method for Determining the Rheological Properties of Asphalt Binder Using Dynamic Shear Rheometer (DSR). Adjust the amount of rejuvenator as necessary to maintain DSR results within a range of 6,000 – 16,000 poises (6 – 16 kPa) when tested at 64 °C (147 °F). Do not continue the work until corrective adjustments are made if two consecutive samples exceed the range for DSR values.

Submit test results electronically to the Engineer and Office of Materials and Testing within 24 hours after samples are taken.

Thoroughly and accurately document the location of the hot in-place recycling mixture replacement for future rehabilitative projects. Future millings obtained from hot in-place recycled mixtures will become the property of the Department. Ensure that millings produced from hot in-place recycled mixtures are not incorporated into GDOT approved RAP stockpiles for use in Hot Mix Recycled Asphaltic Concrete Mixtures.

Section 403—Hot In-Place Recycled Asphaltic Concrete

B. Compaction

The targeted maximum Pavement Mean Air Void content for hot in-place recycled mixtures is 5.0 percent. Ensure that the maximum Pavement Mean Air Voids does not exceed 7.0 or less based on the recycled mixture's theoretical specific gravity measured daily using the T-209 method performed on mixture sampled directly behind the paver. Determine the mixture compaction using either GDT 39, GDT 59 or AASHTO T 331. The method of GDT 39 for "Uncoated Specimens, Dense Graded Mixtures Only" shall not apply when the water absorption of a sample exceeds 2.0 percent, as measured according to AASHTO T 166. In this case, either AASHTO T 331 or the paraffin method of GDT 39 shall apply. The compaction is accepted in lots defined in Subsection 400.3.06. A "Acceptance Plans for Gradation and Asphalt Cement Content" and is within the same lot boundaries as the mixture Meet the compaction requirements of Subsection 400.3.06.B₂ and Subsection 400.5.01.C₂. The Department will perform all compaction testing. Adjust compaction operation if cracking or displacement of the recycled material is observed.

C. Smoothness

The Department will perform acceptance testing for surface course smoothness tolerance using the Laser Road Profiler according to GDT 126. Smoothness testing will be performed on the mainline traveled way and on ramps more than one-half mile (kilometer) in length.

Clean the roadway of any debris and obstructions and provide traffic control to conduct the testing when requested by the engineer.

Ensure the pavement does not exceed a target smoothness index of 900. Do not continue the work until corrective adjustments have been made if the target value is exceeded. Perform corrective work at no expense to the Department by repeating the hot in-place recycling process, according to this Section, if the smoothness index exceeds 1025.

Maintain a 10 ft. (3 m) straightedge in the vicinity of the paving operation at all times to use in measuring minor surface irregularities and provide the labor for its use. Correct all irregularities in excess of 1/8 in (3 mm) in 10 ft. (3 m). Stop the operation until corrective measures are taken when irregularities such as rippling, tearing, or pulling indicate a continuing problem in equipment, mixture, or operating techniques.

D. Mill Depth

Mill heated material to the thickness specified in the plan typical section or contract general notes. Measure thickness acceptance cores obtained randomly as determined by the Engineer in accordance with GDT-73 or five cores per day, whichever is less, to verify mill depth. Additional cores taken for thickness may be required to isolate deficient areas.

The Department will determine the average mill depth based on roadway core measurements according to GDT 42. Mill depth will be determined based on total rejuvenated thickness less any thickness contributed by added virgin materials.

To receive full payment for mill depth, ensure the average milled depth is no less than 1/4 in (6 mm) of that specified in the plan typical section or contract general notes. Apply a pay reduction of 25% to the total square yards (meters) applied that day if the average depth is less than that specified, by more than 1/4 in (6 mm) but no more than 1/2 in (13 mm) of that specified.

Take additional cores to determine the area of deficient depth if the average depth is less than that specified, by more than 1/2 in (13 mm).

E. Corrections

Correct any areas deficient in depth by more than 1/2 in (13 mm) by repeating the hot in-place recycling process at no expense to the Department. Stop the work until corrective measures are made if the average mill depth for two consecutive days is less than 1/4 in (6 mm) of that specified. No individual location shall be recycled more than 2 times. If after the second recycling process, the deficiency is still apparent, mill and in-lay this location with plant produced asphaltic concrete. The plant produced asphaltic concrete shall be equivalent to the recycled design properties.

F. Test Section and Acceptance

The contractor shall be granted a 1 lane mile (1600 m) test section at the beginning of construction to be evaluated by the Office of Materials and Testing for acceptance prior to continuing recycling. If any specified requirement is not obtained, work shall be immediately stopped. If at any time during construction, it is determined that the Contractor's equipment and recycling techniques can not consistently meet requirements, the recycling operation shall be stopped until the Office of Materials and Testing reviews and approves all modifications in equipment and recycling techniques.

Section 403—Hot In-Place Recycled Asphaltic Concrete

The Contractor shall place a 500 ft (152 m) test section to be evaluated and accepted by the Office of Materials and Research prior to resuming recycling.

G. Rutting susceptibility test.

Cores taken each day for depth verification shall be tested according to GDT 115. Maximum deformation shall be 7.0 mm (0.2 in).

403.4 Measurement

Hot in-place recycled asphaltic concrete mixture is measured by the square yard (meter) of the surface area completed and to the depth specified. In computing square yards (meters), the lengths and widths used shall be as specified in Section 109, Measurement and Payment.

Rejuvenating agent, virgin aggregate, and plant-produced asphaltic concrete shall be added as individual components of the recycled mixture as required in the mix design analysis. Include this cost in the unit bid price per square yard (meter). Bituminous materials for tack coat applied and accepted will be measured as outlined in Section 109.

403.4.01 Limits

General Provisions 101 through 150.

403.5 Payment

Hot in-place recycled asphaltic concrete is paid for at the contract unit price per square yard (meter). Payment is full compensation for furnishing all materials, all equipment, Work, and labor. Payment also includes removal of raised pavement markers and thermoplastic striping, if applicable, heating and hot-milling, adding rejuvenator, performing the mix design, performing project sampling and testing, and other incidentals necessary to complete the work. Aggregate and hot mix asphaltic concrete which may be added to meet requirements of the mix design analysis shall be included in the contract unit price.

Bituminous tack coat is paid for per gallon (liter) under separate payment. Hot mix asphaltic concrete specified for overlaying, if any, will be paid for under separate payment. Aggregate specified in the contract, if any, (excluding that required based on the mix design analysis) will be paid for under separate payment.

Payment will be made under:

Item No. 403	Hot in-place recycled asphaltic concrete	Per square yard (meter)
Item No. 403	Hot in-place recycled asphaltic concrete including polymer-modifier	Per square yard (meter)

403.5.01 Adjustments

General Provisions 101 through 150.

Section 407—Asphalt-Rubber Joint and Crack Seal

Delete Section 407 and substitute the following:

407.1 General Description

This work includes filling (Type M) or sealing (Type S) joints and cracks in existing pavements with rubber asphalt mixtures. A polymer-modified asphalt rubber (PMAR) blend may be used in lieu of both Type M and Type S.

407.1.01 Definitions

Type M: Used to fill joints and cracks in Portland cement concrete or asphaltic concrete pavements when required by the Plans before placing an overlay.

Type S: Used to seal joints and cracks in Portland cement concrete and asphaltic concrete pavements and shoulders when not placing an overlay.

407.1.02 Related References

A. Standard Specifications

Section 820—Asphalt Cement

B. Referenced Documents

AASHTO T51

ASTM D 4

ASTM D 36

ASTM D 5329

ASTM D 7173

GDT-2

SOP 22

QPL 92

407.1.03 Submittals

Provide a Certificate of Analysis certifying each lot of premixed material meets the requirements of this Specification and submit the test results of each lot for each Project. Ensure each sealant lot is delivered in containers with the manufacturer's name or trademark and lot number plainly marked.

When instructed by the Engineer, furnish premixed samples and samples of the individual components of premixed material as follows:

- At least 20 lbs (10 kg) of rubber representative of each lot
- At least 5 gal (18 L) of asphalt containing additives as proportioned
- Proportional quantities of mixing aids or additives not included above
- Packaged premixed sealant material weighing no more than 30 lbs (14 kg)

407.2 Materials

Ensure the sealant material is a premixed, asphalt-rubber sealant mixture evaluated in accordance with SOP 22 and listed on QPLs 92-A, 92-B and/or 92-C. Ensure the mixture is a blend of asphalt cement, aromatic extender oil(s), and recycled or reclaimed tire crumb rubber with rubber contents meeting the requirements specified in Table 2. The blending will be

conducted in a closely controlled manufacturing process as detailed in the manufacturer’s submitted Quality Control Plan. Produce a mixture with the following properties:

A. Workability

The mixture pours readily and penetrates a 1/4 in (6 mm) pavement joint or crack to a depth of at least 1 in (25 mm) when the application temperature of the fully reacted mixture is 350 °F (177 °C) and the air temperature is 35 °F (2 °C) or higher.

The mixture, when placed in conventional field installation equipment, readily melts to a pumping consistency after being heated to 400 °F (204 °C) for 2 hours maximum. The mixture remains in a pumping consistency when the temperature of the field installation equipment is reduced to the normal operating temperature range of 300 °F to 350 °F (149 °C to 177 °C).

B. Curing

The mixture contains no water or volatile solvents and cures immediately when cooled to a sufficient viscosity to prevent tracking caused by traffic.

C. Softening Point, Flexibility and Rubber Content.

When a fully reacted mixture sample of asphalt-rubber has been heated at 350 °F (177 °C) for one hour, or when a PMAR blend has been heated at 380 °F (194 °C) for one hour, ensure it passes the following laboratory tests:

1. Softening Point

The minimum softening point by ring and ball described in ASTM D 36 is as follows:

Table 1 – Minimum Softening Point

PMAR	185 °F (85 °C)
Type S	135 °F (57 °C)
Type M	150 °F (65 °C)

2. Flexibility

Bend a 1/8 in (3 mm) thick x 1 in (25 mm) wide x 6 in (150 mm) long mixture specimen after conditioning to 10 °F (-12 °C) at a minimum bending rate of 9 degrees per second(10 seconds maximum for a 90° bend) over a 1 in (25 mm) diameter mandrel without cracking.

3. Rubber Content %

Type M and Type S minimum rubber content % .

Table 2 – Type S and Type M Minimum Rubber Content

Type S	15% minimum
Type M	15% minimum

D. Separation

Test the PMAR blend for phase separation by pouring two representative samples of the mixture into aluminum tubes measuring 1 in (25 mm) in diameter and 5-1/2 in (140 mm) long as described in ASTM D 7173. Cure the samples at 325 °F (163 °C) for 48 hours. Take samples from the top and bottom of each tube and determine softening point as described in ASTM D 36. Average the test results from the top and bottom samples. If there is 4% or more difference between the average test result and either of the top or bottom test results, reject the mixture due to separation.

E. Adhesion

When cooled, the mixture bonds strongly to both asphalt and concrete pavement surfaces. The mixture contains no materials chemically reactive with these surfaces to reduce the short-term and long-term adhesion bonds.

F. Acceptable Recycled or Reclaimed Tire Crumb Rubber

Before the rubber is added, ensure the asphalt cement used in the mixture conforms to the requirements of Section 820.2.01, PG 58-22 or PG 64-22.

Ensure the recycled, reclaimed tire crumb rubber used in the mixture meets the following requirements:

- Obtained from used pneumatic tires (such as automobile, truck, bus, etc.)—not solid tires and non-tire rubber sources
- Produced from an ambient or cryogenic grinding process (crushes, tears, fractures or grinds, the used rubber tires and produces rubber particles with a ragged, sponge-like surface). Tire buffings are prohibited.
- Contains recycled, vulcanized crumb rubber and/or reclaimed (devulcanized) rubber
- Contains at least 25 percent natural rubber by weight of the total rubber portion of the mixture
- Contains no more than 0.1 percent fabric
- Free of wire and other contaminating materials, except up to four percent calcium carbonate or talc to prevent rubber particles from sticking
- Contains no rubber particles greater than 1/4 in (6 mm) long
- Meets the following gradation requirements:

Table 3 – Recycled or Reclaimed Tire Crumb Rubber Gradation

Sieve Size	Percent Passing
No. 10 (2.0 mm)	100%
No. 16 (1.18 mm)	95 to 100%
No. 30 (600 µm)	40 to 80%
No. 80 (180 µm)	0 to 5%

G. Polymer-modified Asphalt Rubber

If a PMAR blend is used, ensure it meets the following additional requirements:

Table 4 – Polymer-modified Asphalt Rubber Properties (PMAR)

PROPERTY	SPECIFICATION LIMITS
Cone Penetration, 77 °F (25 °C) (ASTM D 5329)	30 - 60 dmm
Resilience, 77 °F (25 °C), % Recovery (ASTM D 5329)	30% minimum
Ductility, 77 °F (25 °C), 50 mm/minute (ASSHTO T-51)	300 mm minimum
Asphalt Compatibility (ASTM D 5329)	Pass
Bitumen Content (ASTM D 4)	60 – 70 %
Tensile Adhesion (ASTM D 5329)	350 % minimum
Rotational Viscosity (Brookfield), No. 5 spindle, 20 RPM, 400 °F (205 °C)	3,000 – 15,000 cp
Rubber Content % (GDT-2)	12% minimum

407.2.01 Delivery, Storage, and Handling

Package the premixed sealant material in units weighing no more than 30 lbs (14 kg) with a maximum of two 30 lb (14 kg) units per shipping container. Ensure the plastic film used to package the units melts at normal application temperatures when placed in the installation equipment.

407.3 Construction Requirements

407.3.01 Personnel

General Provisions 101 through 150.

407.3.02 Equipment

A. Field Installation Equipment

Use field installation equipment that produces or maintains specified temperatures, even if filled to capacity.

Ensure the equipment produces or maintains a homogenous mixture of asphalt and rubber at a uniform temperature without hot or cool spots or rubber and asphalt segregation in the mixture.

B. Crack Filling Equipment

Ensure the equipment for filling the joints and cracks directs the sealant into the crack. Seal large cracks from the bottom up. Provide squeegees as necessary.

C. Air Compressor(s)

Ensure the air compressors are satisfactory to the Engineer.

407.3.03 Preparation

A. Joint and Crack Preparation

Use compressed air to thoroughly clean the joints and cracks to be sealed.

Clean the pavement surface and check the joints and cracks to ensure they are free of vegetation, dirt, dust, moisture, and other foreign material.

407.3.04 Fabrication

General Provisions 101 through 150.

407.3.05 Construction

A. Restrictions

Do not seal joints and cracks if:

- The joint or crack surface to be treated is not thoroughly dry.
- Rain is imminent.
- The air temperature is below 35 °F (2 °C).

B. Procedure

Follow this procedure to seal joints and cracks:

1. Place the prepackaged sealant mixture in the field installation equipment.
2. Heat the sealant mixture for the proper time and temperature to provide a full reaction between the asphalt and rubber.
3. Apply the mixture at the specified application temperature according to the manufacturer's recommendations or the laboratory's approval.
4. Carefully fill the joint or cracks, slightly overfull. Strike off the excess with a V-shaped squeegee to feather the sealant out to a width of approximately 2 in (50 mm).

407.3.06 Quality Acceptance

If the packaged units are bonded or stuck together or to the shipping container, or if packaging staples or fasteners cause sealant contamination, the material may be rejected as determined by the Engineer.

The manufacturer must meet the requirements of this Specification and furnish evidence of successful field installation and performance under similar environmental and project conditions.

407.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

407.4 Measurement

Joints and cracks will be measured by the linear foot (meter) by surface measure.

407.4.01 Limits

General Provisions 101 through 150.

407.5 Payment

Joints and cracks sealed according to the Plans and this Specification will be paid for at the Contract Unit Price bid.

Payment is full compensation for furnishing all materials and performing the work.

Payment will be made under:

Item No. 407	Polymer-modified asphalt-rubber joint and crack seal	Per linear foot (meter)
Item No. 407	Asphalt-rubber joint and crack seal, type "S"	Per linear foot (meter)
Item No. 407	Asphalt-rubber joint and crack seal, type "M"	Per linear foot (meter)

407.5.01 Adjustments

General Provisions 101 through 150.

Section 413—Bituminous Tack Coat

Delete Section 413 and substitute the following:

413.1 General Description

This work includes furnishing and applying a bituminous tack coat on a prepared road surface including cleaning the road surface.

413.1.01 Definitions

General Provisions 101 through 150.

413.1.02 Related References

A. Standard Specifications

- Section 109—Measurement and Payment
- Section 400—Hot Mix Asphaltic Concrete Construction
- Section 424—Bituminous Surface Treatment
- Section 427—Emulsified Asphalt Slurry Seal
- Section 820—Asphalt Cement
- Section 822 – Emulsified Asphalt
- Section 824—Cationic Asphalt Emulsion
- SOP 4

B. Referenced Documents

General Provisions 101 through 150.

413.1.03 Submittals

A. Invoices

Furnish formal written invoices from a supplier for the bituminous materials for sole use of tack coat when requested by the Department. Show the following on the Bill of Lading:

- Date Manufactured for emulsified asphalt materials.
- Date shipped
- Quantity in gallons
- Included with or without additives

413.2 Materials

Ensure materials meet the following Specifications:

Table 1 – Bituminous Materials

Material	Section
Asphalt cement, performance grade PG 58-22, PG 64-22, or PG 67-22	820.2.01
Approved non-tracking Anionic Emulsified Asphalt	822.2.01
Cationic emulsified asphalt CSS-1h, CRS-1h, CRS-2h, CRS-3, CQS-1h and other approved non-tracking cationic emulsified asphalt products listed on QPL 7	824.2.01

Use any of the materials shown in Table 1 as bituminous tack coat for work performed under Section 400 as directed by the Engineer.

The Department may change the grade or type of bituminous materials without a change in the Contract Unit Price if the Engineer determines the grade or type selected is not performing satisfactorily.

413.2.01 Delivery, Storage, and Handling

General Provisions 101 through 150.

Emulsified Asphalt

Maintain all equipment used for the delivery, storage, and handling of anionic emulsified asphalt or cationic emulsified asphalt to prevent contamination of the emulsion. Transfer anionic emulsified asphalt or cationic emulsified asphalt directly to the pressure distributor from the transport tanker. Emulsified asphalt may be stored in an onsite bituminous storage tank in accordance with Note 1.

Provide and maintain temperature measuring devices to continuously monitor the temperature of anionic emulsified asphalt or cationic emulsified asphalt in storage and in the pressure distributor. Do not allow anionic emulsified asphalt or cationic emulsified asphalt to freeze.

Note 1: Asphalt emulsion that has been stored longer than 30 days from the time of initial manufacture shall be tested and approved for compliance with specified requirements prior to being used as tack coat for work performed under Section 400.

413.3 Construction Requirements

413.3.01 Personnel

General Provisions 101 through 150.

413.3.02 Equipment

Provide equipment in good repair, including the following units that meet the requirements of Subsection 424.3.02, Equipment.”

- Power broom and blower
- Pressure distributor

Provide a properly cleaned distributor to avoid contamination with incompatible materials.

413.3.03 Preparation

General Provisions 101 through 150.

413.3.04 Fabrication

General Provisions 101 through 150.

413.3.05 Construction

A. Seasonal and Weather Limitation

Do not apply tack coat if the existing surface is wet or frozen. Do not place emulsified asphalt if the air temperature in the shade is less than 40 °F (4 °C).

B. Application

Coat the entire areas to be paved with the tack coat unless directed otherwise by the Engineer. Apply tack coat with distributor spray bars instead of hand hoses, except in small areas inaccessible to spray bars.

Table 2 - Application Rates for Anionic Emulsified Asphalt or Cationic Emulsified Asphalt, gal/yd² (L/m²)

Tack-Uses	Minimum	Maximum
New Asphaltic Concrete Pavement to New Asphaltic Concrete Pavement or Thin Lift Leveling	0.05 (0.23)	0.08 (0.36)
New Asphaltic Concrete Pavement (≤ 25 % RAP) to Aged Existing Pavement or Milled Surface	0.06 (0.27)	0.10 (0.45)

New Asphaltic Concrete Pavement (> 25 % RAP) to Aged Existing Pavement or Milled Surface	0.08 (0.36)	0.12 (0.54)
<ul style="list-style-type: none"> Allow standard anionic emulsified asphalt or cationic emulsified asphalt to break per emulsion manufacturer's recommendation. Proceed with paving only after the anionic emulsified asphalt or cationic emulsified asphalt has cured to the satisfaction of the Engineer. Do not use anionic emulsified asphalt or cationic emulsified asphalt under OGFC or PEM on interstates or limited access state routes. 		

Note: Application rates for PG Binder Asphalt Cement are specified in Section 400.3.03.A.3.C.

C. Temperature of Material

Apply bituminous materials within the temperature ranges specified below.

Table 3 – Bituminous Materials and Application Temperatures

Bituminous Materials	Temperature of Application °F (°C)
Asphalt cement	350 - 400 (175 - 205)
Approved non-tracking Anionic Emulsified Asphalt	140 - 180 (60 - 80)
Cationic Emulsified Asphalt CSS-1h, CRS- 1h,CRS-2h, CRS-3, CQS-1h and other approved non-tracking cationic emulsified asphalt products listed on QPL 7	140 - 180 (60 - 80)

D. Cleaning

Immediately before applying the tack coat, clean the entire area free of loose dirt, clay, and other foreign materials.

E. Application Rate

The Engineer will determine the application rate of the bituminous tack coat.

F. Limitations and Areas Coated

Apply only enough tack coat to the prepared road surface that can be covered with the new pavement course the same working day the tack coat is applied.

G. Maintenance and Protection

After applying a standard emulsified asphalt tack coat material, allow it to break per emulsion manufacturer's recommendation. Do not allow construction equipment or traffic on the tack. When directed by the Engineer, provide a revised paving plan when excessive tracking of the tack material by construction related traffic is evident.

413.3.06 Quality Acceptance

General Provisions 101 through 150.

413.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150 shall apply with specific consideration given to General Provision Sections 105.12, 105.14, and 105.16.

413.4 Measurement

Bituminous materials for tack coat applied and accepted are measured as outlined in Subsection 109.02, "Measurement of Bituminous Materials."

Diluting emulsified tack coat is not ordinarily allowed except when used underneath slurry seal and approved by the Engineer. The composition of diluted emulsified tack coat defined in Subsection 427.3.05, "Construction" is measured by the gallon (liter) of diluted mix.

413.4.01 Limits

General Provisions 101 through 150.

413.5 Payment

The accepted volume of bituminous material will be paid for at the Contract Unit Price per gallon (liter) for bituminous tack coat of the type and grade and approved by the Engineer, complete in place. Payment is full compensation for preparing, cleaning, furnishing, hauling, applying material, and providing incidentals to complete the work.

Payment will be made under:

Item No. 413	Tack coat	Per gallon (liter)
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Section 550—Storm Drain Pipe, Pipe-Arch Culverts, and Side Drain Pipe

Delete Section 550 and Substitute the following:

550.1 General Description

This work includes furnishing and installing the following:

- Storm drain pipe
- Pipe-arch and elliptical culverts
- Side drain pipe flared end sections
- Tapered pipe inlets

Install structures according to the Specifications and the details shown on the Plans, or as directed by the Engineer.

550.1.01 Definitions

Side Drain – All driveway pipes (commercial, non-commercial, residential, utility, farm, logging, and mining).

Thermoplastic Pipe – High Density Polyethylene (HDPE), Polypropylene (PP) and Polyvinyl Chloride (PVC).

General Provisions 101 through 150.

550.1.02 Related References

A. Standard Specifications

Section 205—Roadway Excavation

Section 207—Excavation and Backfill for Minor Structures

Section 208—Embankments

Section 645—Repair of Galvanized Coatings

Section 812—Backfill Materials

Section 815—Graded Aggregate

Section 834—Masonry Materials

Section 840—Corrugated Aluminum Alloy Pipe

Section 841—Iron Pipe

Section 843—Concrete Pipe

Section 844—Steel Pipe

Section 845—Thermoplastic Pipe

Section 847—Miscellaneous Pipe

Section 848—Pipe Appurtenances

B. Referenced Documents

General Provisions 101 through 150.

GDOT Manual on Drainage Design for Highways

Ga. Std. 1030D

Ga. Std. 1030P

GDT 136

550.1.03 Submittals

General Provisions 101 through 150.

550.2 Materials

Ensure materials meet the requirements of the following Specifications:

Material	Section
Backfill Materials	207
Graded Aggregate	815
Reinforced Concrete Pipe	843.2.01
Nonreinforced Concrete Pipe	843.2.02
Mortar And Grout	834.2.03
Bituminous Plastic Cement	848.2.05
Rubber Type Gasket Joints (Concrete Pipe)	848.2.01
Preformed Plastic Gaskets	848.2.06
Corrugated Steel Pipe	844.2.01
Bituminous Coated Corrugated Steel Pipe	844.2.02
Corrugated Aluminum Alloy Pipe	840.2.01
Bituminous Coated Corrugated Aluminum Pipe	840.2.03
Aluminized Type 2 Corrugated Steel Pipe	844.2.06
Ductile Iron Pipe, Fittings and Joints	841
Precoated, Galvanized Steel Culvert Pipe	844.2.05
Smooth Lined Corrugated High Density (HDPE) Polyethylene Culvert Pipe	845.2.01
Polyvinyl Chloride (PVC) Profile Wall Drain Pipe	845.2.02
Polyvinyl Chloride (PVC) Corrugated Smooth Interior Drain Pipe	845.2.03
Smooth Lined Corrugated Polypropylene (PP) Pipe	845.2.05
Miscellaneous Pipe	847

Use any of the following types of pipe:

- Reinforced concrete
- Nonreinforced concrete
- Corrugated steel or Aluminum
- Smooth-lined corrugated high density polyethylene (HDPE)
- Ductile iron
- Polyvinyl Chloride (PVC) Profile Wall Drain Pipe
- Polyvinyl Chloride (PVC) Corrugated Smooth Interior Drain Pipe
- Polymer-Precoated Corrugated Steel
- Smooth Lined Corrugated Polypropylene (PP) Pipe

Use the type of pipe designated on the Plans, or acceptable alternate types when applicable. For a listing of acceptable alternate pipe types see the GDOT Approved Material Selections List in Chapter 7–Storm Drain Design of the Department’s Manual on Drainage Design for Highways. This document summarizes general applications for pipe.

For concrete, corrugated steel and aluminum pipes see Ga. Std. 1030D for minimum thicknesses, minimum cover, maximum fill, allowable pipe diameters and trench construction detail.

For thermoplastic pipes see Ga. Std. 1030P for minimum cover, maximum fill, allowable pipe diameters and trench construction details.

550.2.01 Delivery, Storage, and Handling

General Provisions 101 through 150.

550.3 Construction Requirements

550.3.01 Personnel

General Provisions 101 through 150.

550.3.02 Equipment

General Provisions 101 through 150.

550.3.03 Preparation and Backfill

Before installing pipe, shape the foundation material as shown on the Plans.

Prepare structure excavations, foundation and backfill according to Section 207. Except, use the following foundation and backfill material requirements for thermoplastic pipe installations:

1. For applications located in roadbed, use graded aggregate material meeting Subsection 815.2.01.
2. For applications located outside roadbed:
 - a. Fill heights up to 10 ft (3 m), use normal backfill material meeting the following soil classes per Subsection 810.2.01 and has been pre-approved by the State Materials Engineer.
 - High Density (HDPE) Polyethylene Culvert Pipe use Class II B2 soil or better.
 - Polyvinyl Chloride (PVC) and Polypropylene (PP) Pipe use Class II B3 soil or better.

For pre-approval submit soil classification test results and source location of material to the Office of Materials and Testing. If normal backfill material meeting required Class is not available, use graded aggregate material meeting Subsection 815.2.01.
 - b. Fill heights above 10 ft (3 m), use graded aggregate material meeting Subsection 815.2.01.

550.3.04 Fabrication

General Provisions 101 through 150.

550.3.05 Construction

A. Drainage

Provide necessary temporary drainage. Periodically remove any debris or silt constricting the pipe flow to maintain drainage throughout the life of the Contract.

B. Damage

Protect the structure by providing sufficient depth and width of compacted backfill before allowing construction over a culvert. Repair damage or displacement from traffic or erosion occurring after installing and backfilling at no additional cost to the Department.

C. Installation

Check vertical and horizontal alignment of the pipe culvert or storm drain pipe barrel by sighting along the crown, invert and sides of the pipe, and by checking for sagging, faulting and invert heaving. Repair any issues involving incorrect horizontal and/or vertical alignment before backfilling pipe.

1. Concrete Pipe

Lay sections in a prepared trench with the socket ends pointing upstream. Join section using rubber gasket installed according to Subsection 848.2.01 and the manufacturer's recommendations.

2. Ductile Iron Pipe
Lay pipe sections in a prepared trench, with bells pointing upstream. Construct joints according to Subsection 841.2.02.A.
3. Corrugated Aluminum or Steel Pipe and Pipe-Arches
Lay pipe sections in a prepared trench, with outside laps of circumferential joints pointing upstream and longitudinal joints at the sides. Join the sections with coupling bands, fastened by two or more bolts. Before backfilling the structure repair areas of damaged coatings and exposed base metal according to applicable AASHTO Standard Specification specified in Section 844.
4. Smooth-Lined Corrugated HDPE Pipe
Install smooth-lined corrugated HDPE pipe according to ASTM D 2321 using backfill requirements in Subsection 550.3.03. Use fitting and couplings that comply with the joint performance criteria of AASHTO Standard Specifications for Highway Bridges, Division II. Ensure all joints are "silt tight" as stated in the AASHTO bridge specifications.
5. Specials (Wyes, Tees, and Bends)
Install wyes, tees, and bends as shown on the Plans or as directed.
6. Tapered Pipe Inlets
Locate and install tapered pipe inlet end sections as shown on the Plans or as directed.
7. Elongation
Elongate metal pipe as shown on the Plans. Order the elongation of the vertical axis of the pipe to be done in the shop.
Ensure the manufacturer ship metal pipe with wire ties in the pipe ends. Remove wire-ties immediately after completing the fill.
8. Flared End Sections
Use flared end sections on the inlet, outlet, or on both ends of storm drain pipe, according to Plan details.
9. PVC Drain Pipe
Install polyvinyl chloride (PVC) drain pipe according to ASTM D 2321 using backfill requirements in Subsection 550.3.03. Use fittings and couplings complying with the joint performance criteria of AASHTO Standard Specifications for Highway Bridges, Division II. Ensure all joints are "silt tight" as stated in the AASHTO bridge specifications.
10. Smooth-Lined Polypropylene Pipe
Install smooth-lined polypropylene pipe according to ASTM D 2321 using backfill requirements in Subsection 550.3.03. Use fittings and couplings complying with the joint performance criteria of AASHTO Standard Specifications for Highway Bridges, Division II. Ensure all joints are "silt tight" as stated in the AASHTO bridge specifications.

550.3.06 Quality Acceptance

A. Post Installation Inspection

For projects located on the State Route system, including interstates, inspect 100% of all storm drain pipe and a minimum of 10.0 % of all side drain pipe installations. Conduct post installation inspections in accordance with the requirements of this Specification and GDT 136.

Before post installation inspection, dewater installed pipe (if necessary) and provide the Engineer with a post installation inspection schedule. Notify the Engineer at least seven days in advance of beginning inspection. Perform post installation inspections once compacted backfill has reached a depth of 8 feet or after completion of the pipe installation and final cover, which includes the embankment and all non-asphalt bases and/or subgrades. Notify the Engineer of problems found during the inspection. The Engineer will determine if corrective action is necessary.

Perform post installation inspection with the use of low barrel distortion video equipment with laser profile technology, non-contact video micrometer and associated software.

Video and laser profiling and measurement technology must be certified by the company performing the work to meet the requirements of GDT 136. Inspection contractor personnel completing remote inspections shall be NASSCO – PACP Certified Technicians.

For video recorded, laser profiled pipe indicating deflection is in excess of Specification requirements, the Contractor may elect to further test the pipe with the use of a mandrel. Ensure mandrel meets requirements of GDT 136 and the Engineer has approved before use. Pull the mandrel by hand.

Manual post installation inspection allowed for pipe diameters greater than 48 inches per Subsection 550.3.06.B.

Re-inspect 100% of pipe remediation locations or where replacement was required.

B. Manual Post Installation Inspections

Perform a manual inspection by entering the pipe structure to record video and to make measurements. For all pipe structures considered a confined space, provide entry for all project inspection personnel according to OSHA requirements. Furnish a video recording of each inspection. On the recording, identify the date and time of the inspection, a description of the pipe structure, location, and viewing direction. Record the entire run of pipe. Provide a light source which allows observation of all areas of concern on the video recording. Furnish the video recording in a digital, reproducible format on one of the following media types: DVD or CD.

Measure the deflection of the pipe using either a metal or fabric tape and read to the nearest 0.5 inch (10 mm). Measure crack width using either a crack comparator or a feeler gage capable of measuring 0.01 inch (0.25 mm). Measure joint gaps using a tape or ruler and read to the nearest 0.5 inch (10 mm). Other measuring devices may be used if approved by the Engineer.

Record the measurements and include them in the inspection report. Measure and record the following:

1. The location, length and greatest width of each crack.
2. Smallest inside diameter three times for each pipe section in the run. Take the first measurement vertically from the crown to invert (12 o'clock to 6 o'clock positions). Take the second measurement by rotating 60 degrees from vertical (2 o'clock to 8 o'clock positions). Take the third measurement by rotating 120 degrees from vertical (4 o'clock to 10 o'clock positions). For all measurements, stretch tape to full extent across inside of pipe.
3. Widest gap at each joint in the run.

Record the location and describe other defects not listed above. For each measurement location in a pipe, record the length from the nearest drainage structure.

C. Inspection Report

Submit inspection report to the Engineer after completion of the required post installation inspection. Ensure inspection report meets the requirements of this Specification and GDT 136.

D. Requirements for Concrete Pipe:

1. Joints: Note differential movement, cracks, spalling, improper gasket placement, movement or settlement of pipe sections, and leakage in the inspection report. Repair or replace pipe sections to the satisfaction of the Engineer where joint separation is greater than one inch. Repair or replace pipe sections where soil migration through the joint is occurring.
2. Longitudinal and Transverse Cracks: Cracks with a width less than 0.01 inch (0.25 mm) are considered hairline and minor and only need to be noted in the inspection report, no corrective action is necessary. When cracks are wider than 0.01 inch (0.25 mm) and extend for a length of 12 inch (300 mm) or more, regardless of position in the wall of the pipe, measure the width, length, and locations of the cracks and diameter of the pipe, both horizontally and vertically, use remediation methods in accordance with recommendations of the pipe manufacturer and submit to the Engineer for review and approval an evaluation utilizing a Professional Engineer that takes into consideration structural integrity, environmental conditions, and the design service life of the pipe.

Seal by a method approved by the Engineer cracks having widths equal to or greater than 0.01 inch (0.25mm) that extend for a length of 12 inch (300 mm) or more and determined to be detrimental. Remediate or replace pipe with cracks widths greater than 0.1 inch (2.5 mm) and determined by the Engineer to be beyond satisfactory structural repair. Repair or replace pipes having displacement across the crack.

E. Requirements for Thermoplastic Pipe

1. Joints: Remediate pipe showing evidence of crushing at the joints. Note differential movement, improper joint sealing, movement or settlement of pipe sections, and leakage in the inspection report. Remediate joint separation of greater than 1 inch. Repair or replace pipe sections where soil migration through the joint is occurring.
2. Cracks: Remediate cracks or splits in the interior wall of the pipe. Use remediation methods in accordance with recommendations of the pipe manufacturer and accepted and authorized by the Engineer.

3. Buckling, bulging, and racking: Note in the inspection report flat spots or dents at the crown, sides or flowline of the pipe due to racking. Note areas of wall buckling and bulging in the inspection report. The Engineer will determine if corrective action is necessary.
4. Deflection: Where pipe deflection exceeds 5% of the nominal diameter, submit to the Engineer for review and approval an evaluation utilizing a Professional Engineer taking into consideration the severity of the deflection, structural integrity, environmental conditions, and the design service life of the pipe. Remediate or replace pipe where the evaluation finds the deflection could be problematic or where pipe deflection exceeds 7.5% of the nominal diameter.

F. Requirements for Corrugated Aluminum or Coated Steel Pipe

1. Joints: Remediate pipe showing evidence of crushing at the joints. Note differential movement, improper joint sealing, movement or settlement of pipe sections, and leakage in the inspection report. Remediate joint separation of greater than 1 inch. Repair or replace pipe sections where soil migration through the joint is occurring.
2. Cracks: Remediate cracks or splits in the interior wall of the pipe. Use remediation methods in accordance with recommendations of the pipe manufacturer and accepted and authorized by the Engineer.
3. Buckling, bulging, and racking: Note flat spots or dents at the crown, sides or flowline of the pipe due to racking in the inspection report. Note areas of wall buckling and bulging in the inspection report. The Engineer will determine if an additional evaluation by a Professional Engineer is required. Remediate or replace pipe where the evaluation finds the damaged section could be problematic.
4. Deflection: Where pipe deflection exceeds 5% of the nominal diameter, submit to the Engineer for review and approval an evaluation utilizing a Professional Engineer that takes into consideration the severity of the deflection, structural integrity, environmental conditions, and the design service life of the pipe. Remediate or replace pipe where the evaluation finds the deflection could be problematic or where pipe deflection exceeds 7.5% of the nominal diameter.
5. Coating: Note areas of the pipe where the original coating has been scratched, scoured or peeled in the inspection report. The Engineer will determine if repair is necessary. Use remediation methods in accordance with recommendations of the pipe manufacturer and accepted and authorized by the Engineer.

550.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

550.4 Measurement

A. Excavation and Backfill

Foundation backfill materials types I, II and III are measured according to Subsection 207.4, "Measurement."

Normal backfill is not measured separately, but is included in the measurement of the Items of excavation from which normal backfill materials are obtained.

No measurement will be made for grade aggregate used for structural backfill of thermoplastic pipe.

B. Flat Bottom and Circular Pipe (All Types)

The overall length of pipe installed, excluding tapered inlets, is measured in linear feet (meters), along the central axis of the diameter of the pipe. Wyes, tees, and bends are included in this measurement.

C. Pipe-Arches

The overall length of pipe-arch installed is measured in linear feet (meters), along the bottom center line of the pipe.

D. Multiple Installations

In multiple installations, each single line of culvert structure is measured separately.

E. Tapered Pipe Inlets

Tapered pipe inlet sections are measured as a unit; do not include them in the overall length of the pipe.

F. Flared-End Sections

Flared-end sections are measured separately by the unit and not included in the overall pipe length.

G. Smooth-Flow Pipe

Smooth-flow pipe is measured by the linear foot (meter) along the pipe invert.

H. Elliptical Pipe

Elliptical pipe is measured in linear feet (meters) along the bottom center line of the pipe.

I. Post Installation Inspection

No measurement will be made for post installation inspection.

550.4.01 Limits

Excavation and normal backfill are not measured for payment.

550.5 Payment

A. Backfill

Foundation backfill material Type II and III will be paid for according to Section 207.

Foundation backfill material Type I and normal backfill will be paid for according to Section 205 or Section 206.

Graded aggregate used for structural backfill of thermoplastic pipe will not be paid for separately, payment will be included in the overall price bid for pipe.

B. Pipe Installations

Pipe installations complete in place and accepted will be paid for at the Contract Price for each item.

This payment is full compensation for excavating, furnishing, and hauling materials; installing, cutting pipe where necessary; repairing or replacing damaged sections; post installation inspection, making necessary connections; strutting, elongating, providing temporary drainage; joining an extension to an existing structure where required; and removing, disposing of, or using excavated material as directed by the Engineer.

1. Smooth Flow Pipe

The quantity of each diameter and steel thickness of smooth flow pipe as measured will be paid for at the Contract Unit Price per linear foot (meter) bid for the various sizes. Payment is full compensation for furnishing labor, materials, tools, O-ring mechanical joints, equipment, and incidentals to complete this Item, including removing and disposing excavation material.

2. Flared-End Sections

Flared-end sections, measured as specified above, will be paid for at the Contract Unit Price for each section of the specified size.

Payment will also include sawing, removing, and replacing existing pavement removed to install a new drainage structure.

C. Post Installation Inspection

No separate payment will be made for this work. Include the cost in the bid submitted for this pay item.

Payment for this item is made as follows:

One hundred percent of the Contract Price bid per linear foot (meter) is paid when the pipe is installed per the specifications including the required material documentation. The Contract Price is paid before post installation inspection.

Payment will be made under:

Item No. 550	Storm drain pipe ___ in (mm), H=___	Per linear foot (meter)
Item No. 550	Side drain pipe ___ in (mm), H=___	Per linear foot (meter)
Item No. 550	Pipe arch (span) ___in (mm) x (rise) ___in(mm)	Per linear foot (meter)
Item No. 550	Tapered pipe inlet ___ in (mm),	Per each
Item No. 550	Flared-end section ___ in (mm),	Per each
Item No. 550	Elliptical pipe ___ in (mm) wide x ___ in (mm) high	Per linear foot (meter)

550.5.01 Adjustments

Excavation will not be paid for separately, but the other provisions of Section 205 and Section 208 shall govern.

Section 627—Mechanically Stabilized Embankment Retaining Wall— Contractor Design

627.1 General Description

This Specification covers the required materials, fabrication, construction, measurement, and payment for Contractor designed Mechanically Stabilized Embankment (MSE) retaining walls.

The scope of work of wall erection includes:

- Grading for wall construction
- Compacting the wall foundation
- General and local dewatering as required
- Constructing leveling pads
- Erecting precast panels
- Placing soil reinforcing devices
- Placing and compacting special embankment backfill within the reinforced volume
- Furnishing and placing precast or cast-in-place concrete coping and cast-in-place or precast traffic barrier on top of the wall if shown on the Plans
- Providing downdrag protection for piles
- Furnishing and placing precast or cast-in-place concrete coping and precast or cast-in-place traffic barrier on the top of the wall if these items are shown in the Plans.

The wall foundation includes areas underlying the leveling pad and the reinforced volume. Ensure that items used to construct the mechanically stabilized embankment retaining walls but not mentioned in this Specification conform to the applicable sections of the Standard Specifications.

For patented mechanically stabilized embankment retaining walls, obtain panels, soil reinforcing devices, connecting devices, joint materials, attachments, and expertise to construct the walls.

627.1.01 Definitions

Wall foundation—the area underlying the leveling pad and the reinforced volume.

627.1.02 Related References

A. Standard Specifications

- Section 106—Control of Materials
- Section 208—Embankments
- Section 500—Concrete Structures
- Section 511—Reinforcement Steel
- Section 514—Epoxy Coated Steel Reinforcement
- Section 535—Painting Structures
- Section 645—Repair of Galvanized Coatings
- Section 812—Backfill Materials
- Section 848—Pipe Appurtenances
- Section 865—Manufacture of Prestressed Concrete Bridge Members
- Section 870—Paint

B. Referenced Documents

GDT 75

1992 AASHTO Specifications for Highway Bridges, Section 18, Elastomeric Bearings

627.1.03 Submittals

Submit construction drawings and design notes to the Engineer for review and approval. The submission shall be prepared and stamped by the Design Engineer who shall be registered as a Professional Engineer in the State of Georgia.

Include in the submission, design notes and reproducible drawings concerning the following:

- A. Details, dimensions, and schedules of all reinforcing steel, including dowels and/or studs for attaching the facing to the backfill reinforcement.
- B. Details of backfill stabilizing devices including the length, spacing and size and type material.
- C. For MSE Walls at Bridge Ends:
 - Ensure that MSE wall backfill extends vertically to the bottom of the approach slab.
 - Ensure that the MSE wall backfill extends horizontally to the back of the MSE backfill for the wall below the approach slab or 12 inches (300 mm) beyond the end of the stabilizing devices attached to the bridge, whichever is greater.
 - Show details of attachments to be cast into the bridge endbent, endwall and backwall.
 - Do not make attachments to bridge endwalls that are integral to the bridge superstructure and are subject to movement due to superstructure expansion and contraction.
- D. Use Traffic barrier H, and Cast-in-place Coping B whenever noise walls, light standards, or any other appurtenance is mounted on top of the barrier or coping.

Use Traffic barrier V and Cast-in-place Coping A when no appurtenance is used on top of the barrier or coping.

Traffic barriers shall be cast in place, except that traffic barrier H shall be precast when detailed as precast on the Plans.

- E. Ensure that Plans match GDOT plans in size, format, borders, title block, etc.
- F. Prepare the Plans in “microstation.dgn” format.
- G. Itemize the wall quantities as follows:
 1. Wall Envelope quantities in the Plans.
 2. Changed quantities based on the survey verification of the Wall Envelope (Adjusted Wall Envelope).

The time required for preparation and review of plans and calculations will be charged to the allowable contract time. The final plans and calculations for a wall shall be approved prior to beginning construction on the wall.

The Department will be allowed 45 days to review the plans and calculations and provide either approval or review comments to the contractor. The 45-day review time will begin when the Department has received all of the calculations and drawings concerning the structure. Each new submittal from the Contractor as a result of corrections resulting from the Department's review or changes that are made by the contractor to expedite construction or to correct for field errors will have a 45 day review time.

The Department will be the sole judge of the adequacy of the information submitted. The review and acceptance of the final plans and methods of construction by the Department will not in any way relieve the Contractor of responsibility for the successful completion of the work. Contractor delays due to untimely submissions and insufficient information will not be considered as justification for time extensions.

Within 30 days of receiving Department approval of the plans, submit “stamped” reproducible mylar originals for inclusion in the project plans. Also, submit Electronic files of the final plans. For any changes made during construction of the wall, submit “as built” reproducible mylar originals and “as built” electronic files.

627.2 Materials

Meet the requirements of [Subsection 626.2, "Materials"](#) of the Specifications.

627.3 Construction Requirements

627.3.01 Personnel

Meet the following personnel requirements:

A. Design

Use a Design Engineer with the following qualifications to design the wall and prepare and submit plans for approval:

- Is a registered as a Professional Engineer in the State of Georgia.
- Has knowledge and experience with the design and construction of MSE walls.
- Is available at any time during the life of the Contract to discuss the design of the walls directly with the Department.

B. Construction

The Contractor or Subcontractor shall meet the following requirements:

- Be experienced in the construction of Mechanically Stabilized Embankment Walls.
- Include on staff, a supervising engineer for the Project with at least five years of experience in the construction of Mechanically Stabilized Embankment Walls.

Submit the following proof, whenever requested by the Department, of the ability to design and/or construct Mechanically Stabilized Embankment Walls.

- Evidence of the successful completion of at least five Projects similar in concept and scope to the proposed wall.
- Resumes of the supervising engineer and foremen to be employed on this Project showing the type and number of Mechanically Stabilized Embankment Walls each worked on within the past five (5) years.

The Department will be the sole judge of the acceptability of the qualifications of the design engineer, supervising engineer and foreman.

627.3.02 Equipment

General Provisions 101 through 150.

627.3.03 Preparation

A. General Requirements – Designing and Detailing

The Department's plans will include a Wall Envelope. The Wall Envelope will show:

- The existing and proposed ground line,
- The maximum elevation of the top of the leveling pad
- The proposed top of coping or the proposed gutterline elevations where the barrier is attached to the wall
- The soil parameters for the wall design
- The location of any internal walls required
- The location of other appurtenances including but not limited to:
 - Light standards
 - Sound barriers
 - Sign supports
- Other obstructions in the wall backfill including but not limited to:
 - Drainage structures and pipes
 - Bridge columns, caps, wingwalls

-- Bridge piles

- Details of any proposed ditches at the top of the wall
- Proposed pay quantities

Ensure that the wall design is compatible with all horizontal and vertical criteria and backfill loading conditions.

Verify the wall location according to Subsection 149.1.03.E and Subsection 149.3.03.D before the final wall design is submitted. Include in the verification:

- The top and bottom of the wall envelope
- Backfill design conditions
- Depth of wall embedment
- Location of drainage structures and other obstructions in the wall backfill
- Other appurtenances located on the wall.

If any changes to the wall envelope are required by the field survey, submit plan sheets to the Engineer for approval showing the wall envelope as detailed in the plans with the required changes noted.

B. Wall Design

Use the following design criteria for a Contractor designed wall:

1. Provide one of the following wall systems:
ARES (Tensar Earth Technologies)
Reinforced Earth Wall (The Reinforced Earth Company)
Sine Wall MSE Panel Systems (Sine Wall)
Stabilized Earth Wall (Vistawall Systems)
Tricon Retained Soil Wall (Tricon Precast)
2. Design the MSE Wall according to the current AASHTO Standard Specifications for Highway Bridges including interims. (Mechanically Stabilized Earth Wall Design – Section 5.8)
4. Design the MSE wall to account for all live load, dead load and wind load from all traffic barrier, lights, overhead signs, sound barriers and other appurtenances located on top and adjacent to the wall. Design MSE walls to account for all external forces. Also, design abutment walls for all horizontal and vertical loads applied by the bridge.
5. Assume responsibility for all temporary shoring that may be necessary for wall construction. Design the shoring using sound engineering principles.
6. Use permanent concrete wall facing panels that are at least 7 in (175 mm) thick.
7. Provide a minimum length of soil reinforcement of 10 feet (3 m) or seven-tenths (0.7) of the wall height, whichever is greater.
8. Ensure that the special wall backfill extends a minimum of 12 in (300 mm) past the end of the soil reinforcement.
9. Use the Architectural treatment of facing panels as indicated on the Department's drawings.
10. Provide internal walls to allow for future widening if shown on the wall envelope. Ensure the internal walls have galvanized wire or concrete facing. Ensure as a minimum that the facing of the internal walls extend to the back limit of the MSE Wall Backfill for the permanent wall.
10. Ensure the maximum panel area does not exceed 35 square feet (3.25 square meters).
11. Design the barrier for a 500 lbs. per linear foot (744 kilograms per linear meter) loading applied horizontally along the top of the barrier. The barrier shall be continuous or have a counterweight slab continuous over not less than four panels.
12. A Foundation Investigation Report may be available from the Geotechnical Engineering Bureau of the Department. The information contained in this report may be used by the Contractor to assist in evaluating existing conditions for design as well as construction. However, the accuracy of the information is not guaranteed and no requests for additional monies or time extensions will be considered as a result of the Contractor relying on the information in this report.
13. Ensure the following requirements are met:
The gutterline grade on the proposed top of wall submitted matches the gutter elevations required by the plans.

The top of coping is at or above the top of coping shown on the envelope.

The leveling pad is at or below the elevation shown on the wall envelope.

Any changes in wall pay quantities due to changes in the wall envelope are noted in the contractor's plans

All changes in quantities due to the proposed walls being outside the wall envelope (step locations, ending wall at full panel, etc.) are shown as separate quantities.

14. Ensure the minimum embedment of the wall (top of leveling pad) is at least 2 feet (600 mm). If the soil slopes away from the bottom of the wall, lower the bottom of the wall to provide a minimum horizontal distance of 10 ft (3 m) to the slope. [i.e. a 2:1 slope in front of the wall requires 5 ft (1.5 m) of embedment; a 4:1 slope in front of the wall requires 2.5 ft (750 mm) of embedment]
15. If the Department's review of the submitted plans and calculations results in more than two submittals to the Department by the Contractor, the Contractor will be assessed for all reviews in excess of two submittals. The assessment for these additional reviews will be at the rate of \$60.00 per hour of engineering time expended.

627.3.04 Fabrication

Meet the requirements of Subsection 627.3.04 of the Specifications.

627.3.05 Construction

Meet the requirements of Subsection 627.3.05 of the Specifications.

627.3.06 Quality Acceptance

General Provisions 101 through 150.

627.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

627.4 Measurement

A. Excavation and Shoring

Excavation, including any required removal of unstable material, and shoring necessary for construction of the MSE Wall will not be measured for payment.

B. MSE Wall Face

The area of wall face, complete in place and accepted, will be designated for payment by the square foot (meter) for each height. The area of drains through the Wall will not be deducted.

The wall area measured for payment will be the area from the proposed top of coping or the proposed gutterline or top of sidewalk elevations to the maximum elevation of the top of the leveling pad for each height wall.

Any area of cast-in-place facing around drainage structures within the approved wall envelope will be measured as MSE Wall Face. "Dummy" panels will not be measured for payment.

No separate measurement will be made for internal wall facing.

The entire vertical section of wall will be measured for the greatest height within each section. (i.e. The entire envelope area of a 25 ft (7.62 m) long section of wall that measured from 12 ft (3.66 m) high to 18 ft (5.5 m) high will be measured for payment as MSE Wall Face, Wall No. _ [$>10'$ - $20'$ (3 – 6 m) ht].

The height will be measured from the maximum elevation of the top of the leveling pad to the:

1. Top of Coping or,
2. Gutterline Elevation at the Barrier or,
3. Top of Sidewalk at Parapet

C. Backfill Stabilizing Devices

The backfill stabilizing devices will not be measured separately.

D. Backfill

The MSE backfill material used in the MSE wall volume will not be measured separately except as noted below.

- The MSE Backfill required behind bridge endwalls or backwalls and above the top of coping will be measured as additional MSE wall backfill.
- Any additional MSE backfill required as a result of an undercut ordered by the Engineer and requiring the MSE backfill material to provide stability, as determined by the Engineer, will be measured and paid for as additional MSE wall backfill.

Backfill of undercut areas not requiring classes of soils higher than common excavation soils will not be measured separately.

Backfill material required by construction procedures to extend outside the MSE wall volume shall be considered incidental and will not be measured separately.

E. Concrete Leveling Pads

Concrete Leveling Pads will not be measured separately.

F. Cast-in-place Coping A, Cast-in-place Coping B, Precast Coping, Traffic Barrier V, Traffic Barrier H, mounted atop the MSE Wall

These units complete in place and accepted, will be designated on the Plans and measured per linear foot (meter) for each type unit.

The quantities of coping and barrier will be measured as horizontal lengths in linear feet (meters).

627.4.01 Limits

General Provisions 101 through 150.

627.5 Payment

The pay quantities will be the Wall Envelope quantities shown in the Plans unless the Engineer approves an adjusted wall envelope. In this case, the pay quantities will be the adjusted wall envelope quantities.

No additional compensation will be made for any additional material, equipment, design, or other items found necessary to comply with the project Specifications as a result of the Department's review except for changes made necessary by the survey verification required by Subsection 149.1.03.E and Subsection 149.3.03.D, or other changes approved by the Engineer.

Include in the unit bid prices all costs necessary to comply with the requirements of this specification. No payment will be made for wall area outside of the adjusted wall envelope.

A. Excavation and Shoring

Excavation, including removing unstable material and shoring for construction of the mechanically stabilized embankment retaining wall, will not be paid for separately.

B. MSE Wall Face

The area of wall face, complete in place and accepted, will be paid for by the square foot (meter) for each height. The area of drains through the wall will not be deducted.

Any area of cast-in-place facing around drainage structures within the approved wall envelope will be paid as wall face. Payment will include all costs for concrete, reinforcing steel in the cast-in-place areas. No additional payment will be made for any "dummy" panels required.

If the wall height changes to a height greater than the maximum included in the pay items, the area of wall with a height greater than the maximum will be paid at 120% of the bid price of the maximum height pay item included in the plans.

The entire vertical section of wall will be paid at the unit price for the greatest height within each section. (i.e. The entire envelope area of a 25 foot (7.62 m) section of wall that measured from 12 ft (3.66 m) high to 18 ft (5.5 m) high will be paid as MSE Wall Face, Wall No. _ [$>10'$ - $20'$ (3 – 6 m) ht]

No separate payment will be made for architectural treatment.

No separate payment will be made for internal wall facing, internal wall backfill stabilizing devices or additional MSE backfill necessitated by the internal wall.

C. Backfill Stabilizing Devices

The backfill stabilizing devices will not be paid for separately. Include this cost in the unit price bid for MSE wall face.

D. Backfill

The MSE backfill material used in the MSE wall volume will not be paid for separately except as noted below. When not paid for separately, include the cost in the unit price bid for MSE wall face.

Exceptions:

- The cost of MSE Backfill required behind bridge endwalls or backwalls and above the top coping will be paid for as Additional MSE Wall Backfill.
- Any additional MSE backfill required as a result of an undercut ordered by the Engineer and requiring the MSE backfill material to provide stability, as determined by the Engineer, will be paid as additional MSE wall backfill.
- If no quantities for this item are included in the proposal, a price of \$25 per cubic yard (\$33.00 per cubic meter) will be paid.

Backfill of undercut areas not requiring materials of grades higher than common excavation soils will not be paid for separately. Include the cost in the overall bid price submitted.

Any backfill material required by construction procedures to extend outside the MSE Wall volume is considered incidental. Include this cost in the price bid for contract items.

E. Concrete Leveling Pads

Concrete leveling pads, including steps shown in the Plans will not be paid for separately.

F. Cast-in-place Coping A, Cast-in-place Coping B, Precast Coping, Traffic Barrier V, Traffic Barrier H, mounted atop the MSE Wall

These units, complete in place and accepted, will be designated on the Plans and paid for at the Contract Unit Price bid per linear foot (meter) for each type unit.

G. Dewatering

No separate payment will be made for dewatering. Include the cost of dewatering in the price bid for special embankment backfill.

Payment will be made under:

Item No. 627	MSE wall face, wall No. __0 -10 ft (0 -3 m)	Per square foot (meter)
Item No. 627	MSE wall face, wall No. __ >10 -20 ft (3 -6 m)	Per square foot (meter)
Item No. 627	MSE wall face, wall No. __ >20 - 30 ft (6 -9 m)	Per square foot (meter)
Item No. 627	MSE wall face, wall No. __ >30 ft (6 -9 m)	Per square foot (meter)
Item No. 627	Coping, A, wall No. ____	Per linear foot (meter)
Item No. 627	Coping, B, wall No. ____	Per linear foot (meter)
Item No. 627	Traffic barrier, H, wall No. ____	Per linear foot (meter)
Item No. 627	Traffic barrier, V, wall No. ____	Per linear foot (meter)
Item No. 627	Additional MSE backfill	Per cubic yard (meter)

627.5.01 Adjustments

General Provisions 101 through 150.

Section 636—Highway Signs

Delete Section 636 and substitute the following:

636.1 General Description

This work includes fabricating and installing highway signs according to the details on the Plans and the Manual on Uniform Traffic Control Devices.

636.1.01 Definitions

General Provisions 101 through 150.

636.1.02 Related References

A. Standard Specifications

- Section 500—Concrete Structures
- Section 830—Portland Cement
- Section 855—Steel Pile
- Section 870—Paint
- Section 910—Sign Fabrication
- Section 911—Sign Posts
- Section 912—Sign Blanks and Panels
- Section 913—Reflectorizing Materials
- Section 914—Sign Paint
- Section 915—Mast Arm Assemblies
- Section 916—Delineators
- Section 917—Reflective and Nonreflective Characters

B. Referenced Documents

Manual on Uniform Traffic Control Devices

636.1.03 Submittals

Before fabricating overhead panel type signs, submit to the Engineer the Shop Drawings to approve the sign bracing and method of attaching to sign supports.

Before driving piles, furnish a list of proposed pile lengths to the Engineer.

636.2 Materials

Ensure that materials meet the requirements of the following Specifications:

Material	Section
Sign Fabrication and Accessories	910
Steel Sign Posts and Bolts (Drive Type)	911.2.01
Galvanized Steel Structural Shape Posts	911.2.02
Delineator Posts	
Galvanized Steel	911.2.04.A.4
Aluminum "U" Flange	911.2.04.A.5
Wood	911.2.04.A.6

Material	Section
Flexible	911.2.04.A.7
Aluminum Sign Blanks	912.2.01
Extruded Aluminum Sign Panels	912.2.02
Reflective Sheeting	913.2.01
Silk Screen Lettering Paint	914.2.01
Steel Posts and Arms for Mast Arm Assembly	915.2.01
Guy Wires for Mast Arm Assembly	915.2.02
Center Mount Reflector	916.2.01
Demountable Characters with Reflective Sheeting	917.2.01
Fittings, bolts, nuts, washers, clips, molding, etc., for panel signs shall conform to the requirements shown on the Plans.	
Class A Concrete Footings for Signs	500
Piling	855.2.03
Portland Cement	830.2.01
Sign Paint, Enamel	870.2.03

636.2.01 Delivery, Storage, and Handling

General Provisions 101 through 150.

636.3 Construction Requirements

636.3.01 Personnel

General Provisions 101 through 150.

636.3.02 Equipment

General Provisions 101 through 150.

636.3.03 Preparation

General Provisions 101 through 150.

636.3.04 Fabrication

General Provisions 101 through 150.

636.3.05 Construction

A. Finished Signs

Ensure that the finished signs are clear cut and that the lines of letters and details are true, regular, and free of waviness, unevenness, furry edges or lines, scaling, cracking, blistering, pitting, dents, or blemishes.

Only one type of demountable characters (letters, numerals, symbols, and borders) is permitted on special roadside signs on each Project.

B. Erecting the Signs

1. Drive Type Posts

Drive type posts may be driven in place or placed in prepared holes.

- a. Use driven posts only in firm and stable soil. If the soil is sandy or unstable, place each drive type post in a prepared dry hole of at least a 4 in (100 mm) diameter.
- b. When placing posts in prepared holes:
 - 1) Backfill the holes with a mixture of damp, clean friable soil and 8 percent by volume Portland cement.
 - 2) Thoroughly tamp the mixture in place around the posts.
- c. Erect posts vertically as deep and at an angle to the roadway as shown on the Plans or as directed.

- d. Do not penetrate posts in the coastal plain region less than 4 ft (1.2 m) or 3 ft (1 m) for posts in the Piedmont and the Valley and Ridge Regions when no guard rail is present.
When erecting signs behind a guard rail, penetrate at least 3 ft (1 m) for posts 14 ft (4.2 m) or less long, or 4 ft (1.2 m) for posts over 14 ft (4.2 m) long.

2. Single-Plate Signs

Erect single-plate signs 9 ft² (0.84 m²) or less on one drive-type post unless otherwise specified on the Plans.

Erect single-plate signs greater than 9 ft² (0.84 m²) on two drive-type posts.

Leave enough distance between the two posts to fit the mounting holes in the sign plate.

3. Steel Posts for Mast Arm Assemblies

- a. Erect steel posts for mast arm assemblies in a concrete foundation according to the Plans. Erect at the place, height, and angle to the roadway specified.

- b. After curing the concrete foundation for at least 24 hours, securely fasten the specified signs into place on the mast arm.

4. Ground-Mounted Panel-Type Signs

- a. Erect the supporting members of ground-mounted panel-type signs where shown on the Plans or as directed by the Engineer at the specified angle to the roadway.

- b. Securely fasten the panels into place.

5. Milepost Signs

Erect milepost signs including posts as specified on the Plans.

6. Delineator Posts

Use delineator posts made of galvanized steel, aluminum, or an alloy that conforms to the requirements of Subsection 911.2.04.A.4 or 911.2.04.A.5.

- a. Erect the posts where shown on the Plans.

- b. Mount reflectors for galvanized steel or aluminum posts on the flange side of the post.

- c. When signs are attached to supports, torque the bolts to at least 20 ft-lbs (27 N•m).

7. Overhead Panel-Type Signs

Erect overhead panel type signs on sign supports where shown on the Plans or as directed by the Engineer.

- a. Ensure that the bottom of the sign is 18 in (450 mm) above the top of the lighting fixture.

- b. Ensure that the sign has ample bracing for mounting the sign support so that each sign can withstand 1 in (25 mm) of ice accumulated on the entire sign and wind pressures shown on the Plans.

- c. Ensure that the top of each sign is three degrees off perpendicular from the bottom of the sign. Use the three-degree slant to lean the sign toward the approaching traffic.

C. Foundations (for Special Roadside Signs)

Do not disturb the natural ground adjacent to a foundation more than necessary to construct the footing.

1. Excavate for the footings to the lines and elevations shown on the Plans or established by the Engineer. Do not disturb or loosen the foundation below these elevations.

2. Use forms of the necessary shape and dimensions to construct the footings to the lines and elevations shown on the Plans.

3. Cure the concrete foundations, constructed in conformance with Section 500 and the Plan details, at least 7 days before erecting the sign.

4. Ensure that the minimum lengths of steel H piling used in the foundations of ground-mounting signs are accepted and meet the Plan penetration requirements.

The Plan quantity of steel H piling is shown for estimating purposes only; determine and provide the necessary lengths of piles.

5. Before driving the piles, furnish a list of proposed pile lengths to the Engineer.

- a. Use full-length piles or built-up piles with a maximum of two splices that are made in the presence of the Engineer.

- b. Furnish satisfactory identification for all piles or portions thereof.

6. When rock prevents the penetration required on the Plans, construct according to the notes and details shown on the Plans.
7. The minimum energy ratings required by Section 520 for pile hammers will be waived for constructing ground-mounted sign supports. Jetting is not permitted.
8. Place required backfilling in layers no greater than 6 in (150 mm) thick and thoroughly compact it to the approximate density of the undisturbed soil in the area.

D. Sign Panels

Use extruded, panel-type aluminum. Ensure that the sign type used meets the requirements of Subsection 912.2.02.

E. Legends and Borders

Place legends and borders according to Subsection 917.2.01, "Demountable Characters", with Type XI reflective sheeting.

636.3.06 Quality Acceptance

General Provisions 101 through 150.

636.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

636.4 Measurement

A. Type-1 or Type-2 Highway Signs

Type 1 or Type 2 highway signs with reflective sheeting of Type IX or XI as specified on the Plans to be paid for are measured for payment by the actual number of square feet (meters) and fraction thereof of sign type and sheeting specified. The measurement includes providing the message and furnishing and placing signs complete and accepted. The Plan quantity will be the pay quantity.

B. Extruded Aluminum Panels

Extruded aluminum panels to be paid for are the number of square feet (meters) or portion of square feet (meters) furnished, including legend components, border material, fittings, nuts, washers, clamps, molding, etc., furnished, erected, completed, and accepted.

C. Galvanized Steel Posts

Galvanized steel posts, types 7, 8, or 9 to be paid for are the actual number of linear feet (meters) and fraction thereof of the type specified, furnished, erected, completed, and accepted.

Galvanized steel to be paid for is the number of pounds (kilograms) furnished, erected, and accepted. Weights are computed from theoretical weights listed in the Plans for each post size. Base plates, connections, anchors, stub post, etc., are not measured for payment but are considered incidental to the Item.

D. Delineators

Delineators (reflectorized guide markers) to be paid for are the number of the type specified, including posts, rivets, and spacers, that are furnished, placed, and completed and accepted.

E. Mast Arm Assemblies

Mast arm assemblies to be paid for are the actual number furnished and erected, including concrete footing, sign, and post, completed and accepted.

F. Special Roadside Signs

Class A concrete for special roadside signs to be paid for are measured by the cubic yard (meter), neat measurement according to Section 500.5 "Payment." No deductions are made for the volume of concrete displaced by steel piling, anchor bolts, or posts.

G. Portland Cement

Portland cement stabilized material used for backfilling holes is not measured for payment.

H. Steel H—Piling

Steel H—piling is measured for payment by the linear foot (meter) of accepted piling in place (signs), remaining in the completed work.

636.4.01 Limits

General Provisions 101 through 150.

636.5 Payment

Highway signs, galvanized steel posts, I-beam posts, delineators, mast arm assemblies, Class A concrete, and piling for signs are paid for at the Contract Unit Price for the various items. Payment is full compensation for furnishing and erecting the Item complete in place according to this Specification.

Separate payment will not be made for piling splices, the cost of cutting, or the cutoff portions. Pile cutoffs remain the Contractor's property.

Piles eliminated due to authorized revisions will be paid for according to Subsection 109.06, "Eliminated Items." These piles become Departmental property. Except for the above provision, no payment will be made for piles delivered to the Project that are not used in the work.

Payment will be made under:

Item No. 636	Highway signs, type 1 material, reflective sheeting type____,	Per square foot (meter)
Item No. 636	Highway signs, type 2 material, reflective sheeting type____,	Per square foot (meter)
Item No. 636	Galvanized steel posts, type ____	Per linear foot (meter)
Item No. 636	Galvanized steel structural shape posts	Per pound (kilogram)
Item No. 636	Highway signs, aluminum extruded panels, reflective sheeting type ____	Per square foot (meter)
Item No. 636	Plastic Flexible Delineator, type____	Per each
Item No. 636	Delineator, Type____	Per each
Item No. 636	Piling in place, signs, steel H, HP 12x53 (HP 310x79)	Per linear foot (meter)

636.5.01 Adjustments

General Provisions 101 through 150.

Section 641— Guardrail

Delete Subsection 641 and substitute the following:

641.1 General Description

This work includes furnishing and erecting guardrail and appurtenances according to the Specifications. Conform with the lines, grades, and locations shown on the Plans or as directed.

Place W-beam, T-beam, or “T” beam with modified offset block as shown on the Plans and in the Proposal. Unless designated otherwise, references to guardrail shall mean W-beam.

Unless provided for in the Plans, this work also includes:

- Grading to provide the “T” distance shown on the standard behind the guardrail
- Grading to construct shoulder flares for approved guardrail anchorage systems and widened shoulders along Guardrail runs according to Section 205 and Section 208
- Furnishing and setting additional posts (all lengths) together with the necessary offset blocks and hardware (when specified in the Plans or in the Proposal)

641.1.01 Definitions

General Provisions 101 through 150.

641.1.02 Related References

A. Standard Specifications

Section 205—Roadway Excavation

Section 208—Embankments

Section 600 – Controlled Low Strength Flowable Fill

Section 645—Repair of Galvanized Coatings

Section 700—Grassing

Section 859—Guardrail Components

Section 870—Paint

B. Referenced Documents

General Provisions 101 through 150.

QPL-64

National Cooperative Highway Research Program (NCHRP) Report 350

American Association of State Highway and Transportation Officials (AASHTO) Manual of Assessing Safety Hardware (MASH)

641.1.03 Submittals

General Provisions 101 through 150.

641.2 Materials

A. Steel Guardrail

Use steel Guardrail and steel posts unless specified otherwise on the Plans or in the Proposal.

B. Guardrail Auxiliary Items

Ensure that the guardrail includes auxiliary materials and Work to make connections and other guardrail or structures required to complete the construction indicated on the Plans.

C. Offset Blocks

Except at locations approved by the Engineer, use plastic offset blocks according to Subsection 859.2.05 “Plastic Offset Blocks” for “W” beam guardrail installation. Offset blocks for “T” beam guardrail installations shall be plastic, or modified steel offset blocks per the Standard Plans including Construction Details and Section 859. When approved by the Engineer, use treated wood offset blocks according to Subsection 859.2.04, “Wood Guardrail Posts and Offset Blocks.” only in isolated areas of “W” beam or “T” beam guardrail installations, where standard size blocks would not provide a satisfactory fit.

Wood offset blocks and/or wood posts may be specified within the limits of an approved guardrail terminal. Use only one type of offset block within continuous runs of guardrail except in transitions or where specified in the Plan details.

Ensure that materials meet the requirements of these Specifications:

Material	Section
Guardrail Elements and Fittings	859.2.01
Cable End Anchor Assembly	859.2.02
Steel Post and Offset Blocks	859.2.03
Wood Post and Offset Blocks	859.2.04
Plastic Offset Blocks	859.2.05
Galvanized Repair Compound	870.2.05

641.2.01 Delivery, Storage, and Handling

General Provisions 101 through 150.

641.3 Construction Requirements

641.3.01 Personnel

General Provisions 101 through 150.

641.3.02 Equipment

General Provisions 101 through 150.

641.3.03 Preparation

General Provisions 101 through 150.

641.3.04 Fabrication

A. Guardrail Anchorages, Mounting Devices, and Brackets

Fabricate and install guardrail anchorages, mounting devices, brackets, and other appurtenances according to the Plan details or as approved by the Engineer.

641.3.05 Construction

A. Erection of Posts

1. Wood guardrail posts shall not be used at any location except as required for guardrail terminals and guardrail anchorage.
2. Set the posts in post holes or drive them vertically at the positions, depth, spacing, and alignment shown on the Plans.
3. Install posts for Guardrail on bridges or other structures as detailed on the Plans.
4. Backfill post holes to the ground line with approved material tamped in place in layers of not more than 4 in (100 mm) thick.

5. If posts are driven, protect the tops of the posts with a suitable driving mat or cap. Remove and replace posts damaged during driving, at no additional cost.
6. Backfill the post holes that are drilled in rock as indicated on the Plans or directed by the Engineer.
7. Remove and reset posts that are out of alignment or too low in grade. Do not cut off posts that are too high; drive them to the proper elevation. Do not deviate more than 1/4 in (6 mm) vertical and horizontal post alignment.
8. Fit the posts with an offset block according to this Specification and Plan details.
9. Set additional posts and appurtenances, when required, according to the requirements of this Section and the Plan details.
10. When necessary to place posts in existing pavement, slope paving, etc., exercise extreme care in the cutting process, protect the adjacent areas, and remove all loose material. Cut holes in the existing paved area by drilling or sawing according to the Plan details. Replace the pavement material according to the Plan details with a controlled low strength flowable fill that has a maximum 28-day compressive strength of 100 psi according to Section 600.

B. Erection of Rail

Erect the rails to attain a smooth, continuous rail line that conforms to the line and grade of the highway.

Determine the height of the rail from the dimensions shown on the Plans. Use bolts long enough to extend at least 1/4 in (6 mm) beyond the nuts after they are firmly tightened.

Install reflectorized washers on guardrail and anchorages. Where double faced guardrail is located on the inside shoulder of medians, install reflectorized washers only on the side which is nearest to traffic. Install reflectorized washers according to this Specification and Plan details.

C. Damaged Spelter Coating

Repair damaged spelter coating according to the requirements of Section 645.

D. Guardrail Terminals

Guardrail terminals shall be designed for use with "W" beam guardrail installations, which has been approved by FHWA as meeting NCHRP-350 and/or MASH Test Level 3 (TL-3) and listed on the Office of Materials and Testing Qualified Products List QPL-64. Where the terminal is connected to "T" beam guardrail installations, a transition is required as shown in the Standard details.

Construct guardrail terminals according to the manufacturer's requirements except for the grading which will be as shown in the Plans and as directed by the Engineer. Obtain copies of the manufacturer's details and installation instructions and provide copies of the same to the Engineer prior to the installation of the unit. Provide a FHWA letter of approval for NCHRP-350 and /or MASH, TL-3 compliance of the guardrail terminal to be used. Yellow and black nose striping, as shown on the Plans will be required on all guardrail terminal.

641.3.06 Quality Acceptance

General Provisions 101 through 150.

641.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

641.4 Measurement

A. Guardrail

Guardrail of the type specified is measured in linear feet (meters), including terminal sections when installed. Measurement does not include guardrail terminals or guardrail anchorage assembly.

When double faced guardrail of the type specified is installed, the single guardrail on each side of the posts is not measured separately. Each single rail is a component part of the double faced guardrail installation.

B. Guardrail Terminal and Anchorage Assembly

This Item is measured by the number of each type installed according to the details shown on the Plans.

C. Guardrail Posts

All lengths of guardrail posts when shown in the Plans or Proposal as a separate payment Item are measured by the Unit.

641.4.01 Limits

General Provisions 101 through 150.

641.5 Payment

Guardrail, of the type specified, complete in place including posts, offset blocks, and hardware will be paid for at the Contract Price per linear foot (meter).

Guardrail terminals and guardrail anchorage assemblies will be paid for at the Contract Price per each assembly, complete in place.

All lengths of guardrail posts when shown in the Contract documents as a separate Pay Item will be paid for at the Contract Unit Price. Payment is full compensation for furnishing the posts, offset block, hardware, and Work to complete the Item.

For Projects that do not include grading as a Pay Item, payment for guardrail and guardrail anchorage systems on shoulders includes:

- Embankment material for shoulders as shown on the Standard Details or Plans
- Compacting embankment material for shoulders to the approximate density of the surrounding soils
- Removing existing vegetation and obstructions before placing the embankment
- Grassing the reconstructed area according to Section 700

Payment will not be increased or decreased when wood offset blocks are added to or substituted for steel or plastic offset blocks.

Payment will be made under:

Item No. 641	Guardrail, type_____	Per linear foot (meter)
Item No. 641	Double faced guardrail, type_____	Per linear foot (meter)
Item No. 641	Guardrail for bridges, type_____	Per linear foot (meter)
Item No. 641	Double guardrail for bridges, type_____	Per linear foot (meter)
Item No. 641	Guardrail, Type T, Modified offset block	Per linear foot (meter)
Item No. 641	Guardrail terminal, type _____	Per each
Item No. 641	Guardrail anchorage, type____,	Per each
Item No. 641	Guardrail posts (all lengths)	Per each

641.5.01 Adjustments

General Provisions 101 through 150.

Section 647—Traffic Signal Installation

Delete Section 647 and substitute the following:

647.1 General Description

This work consists of furnishing materials and erecting a traffic signal installation including all traffic signal equipment, poles, bases, wires and miscellaneous materials required for completion of the installation. Ramp Meters are defined as a form of traffic signalization and all general provisions for traffic signalization are applicable unless otherwise noted in the Plans and Specifications.

It also includes all test periods, warranties and guarantees as designated in subsequent sections, and response to maintenance and operational issues as described in subsequent sections.

Apply for, obtain and pay for all utility services, communications services to, and pole attachment permits required by all utility owners that are necessary for the signal installation and operation required in the Plans. The Contractor will be responsible for establishing utility services and ongoing monthly costs related to utility services until final acceptance of the signal project.

Upon completion of a successful “burn in” or operational testing period for the signal installation, the Contractor will be responsible for an orderly and uninterrupted transfer of these services and permits to the local government or other jurisdiction that will be responsible for subsequent maintenance and operation.

647.1.01 Definitions

General Provisions 101 through 150.

647.1.02 Related References

A. Standard Specifications

Section 106—Control of Materials

Section 107—Legal Regulations and Responsibility to the Public

Section 108 —Prosecution and Progress

Section 150 —Traffic Control

Section 500—Concrete Structures

Section 501—Steel Structures

Section 535—Painting Structures

Section 615—Jacking or Boring Pipe

Section 631—Changeable Message Signs

Section 636 – Highway Signs

Section 639—Strain Poles for Overhead Sign and Signal Assemblies

Section 645—Repair of Galvanized Coatings

Section 680—Highway Lighting

Section 681—Lighting Standards and Luminaires

Section 682—Electrical Wire, Cable, and Conduit

Section 700—Grassing

Section 755—Electrical Work
Section 800—Coarse Aggregate
Section 801—Fine Aggregate
Section 832—Curing Agents
Section 833—Joint Fillers and Sealers
Section 850—Aluminum Alloy Materials
Section 852—Miscellaneous Steel Materials
Section 853—Reinforcement and Tensioning Steel
Section 854—Castings and Forgings
Section 861—Piling and Round Timber
Section 870—Paint
Section 886—Epoxy Resin Adhesives
Section 910—Sign Fabrication
Section 911—Steel Sign Posts
Section 912—Sign Blanks and Panels
Section 913—Reflectorizing Materials
Section 915—Mast Arm Assemblies
Section 922—Electrical Wire and Cable
Section 923—Electrical Conduit
Section 924—Miscellaneous Electrical Materials
Section 925—Traffic Signal Equipment
Section 926 – Wireless Communication Equipment
Section 927 – Wireless Communication Installation
Section 935—Fiber Optic System
Section 936—CCTV System
Section 937—Video Detection System
Section 939—Communications & Electronic Equipment
Section 940—Navigator Integration

B. Referenced Documents

National Electrical Manufacturers Association (NEMA) Traffic Control Systems Standards No. TS 1
NEMA Traffic Control Systems Standards No. TS 2
AASHTO Roadside Design Guide
The Manual on Uniform Traffic Control Devices (MUTCD), current edition
National Electrical Code
National Electrical Safety Code (NESC)
GDT 7 Determining Maximum Density of Soils

GDT 24a Determining the Theoretical Minimum Dry Density of Soils or Soil Aggregates containing > 45% Retained on the No. 10 Sieve

GDT 24b Determining the Theoretical Minimum Dry Density of Soils or Soil Aggregates containing > 5% Retained on 2-Inch Sieve using a 5.5 Pound Rammer and a 12 Inch Drop

GDT 67 Family of Curves Method for Determining Maximum Density of Soils

647.1.03 Submittals

Use only equipment and materials that are on the Department's Qualified Products List (QPL

These products have been evaluated by the Office of Traffic Operations and have proven their capability of meeting the appropriate Georgia Department of Transportation Specification. Any of these products may be used without sampling or pre-testing. The Contractor shall submit a letter to the Field Engineer, stating which QPL items they will use.

Submittal letter shall include QPL number-and product description.. The Field Engineer and/or department designee must ascertain that the construction item is the same material identified on the appropriate QPL and will acknowledge receipt of these items in the project diary or as required by the Construction manual.

Written approval is required from the State Traffic Engineer or District Engineer prior to beginning any work on the traffic signal installation and /or installing the proposed on the work site.

A. Review

For all traffic signal material submittals, the Engineer's review of the material should be completed within forty five (45) days from the date of receipt of the submission unless otherwise specified. The State Traffic Engineer or District Engineer will advise in writing, as to the acceptability of the material submitted.

The State Traffic Engineer or District Engineer may determine that submitted equipment is approved, in which no further action is required. In the event, materials submitted for use are rejected the Contractor is required to re-submit materials, within fifteen (15) days of notification of material failure or rejection. Resubmittal of subsequent materials for review will be considered the start point of a new approval cycle as described.

The Department reserves the right to be reimbursed by the Contractor for reviewing any equipment and/or component submittals after a second submittal of equipment proposed for use on the project.

B. Submittal Costs

No separate measurement or payment will be made for submittal costs. All costs associated with reproduction of submittal material documents, samples and mailing expensed will be the responsibility of the Contractor and are not subject to reimbursement by the Department. All submittal material becomes the property of the Department and will not be returned to the Contractor.

C. Steel Strain Pole, Concrete Strain Pole or Steel Pole Certification

Instruct the supplier or manufacturer of the strain poles or steel poles with traffic signal mast arms to submit a certification, including mill certificates to:

Department of Transportation

Office of Materials and Research

15 Kennedy Drive

Forest Park, Georgia 30297

Include the following in the certification:

- A statement that the items were manufactured according to the Specifications, including the Specification Subsection number
- Project number and P.I. number

Instruct the supplier or manufacturer to send copies of the transmittal letter to the Engineer.

Prepare Shop Drawings and related signal strain pole design calculations with the following criteria, 5% sag and 18 foot signal head height. Provide “bending moment at yield” to determine the foundation size according to the signal strain pole foundation drawings. Submit all Shop Drawings and related signal strain pole design calculations to the Traffic Engineer. The Traffic Engineer will forward to the State Bridge and Structural Design Engineer for review and approval. Obtain written approval prior to pole fabrication and installation. Upon acceptance of the pole certification provide one copy of the design calculations and shop drawings to the agency responsible for maintaining the traffic signal installation.

All pole drawings shall include roadway and pole elevations.

Show all dimensions and material designations of the designs on the Drawings. See Subsection 501.1.03 for the certification procedure for poles and anchor bolts.

D. Signal Item Certification

Only Equipment and/or material on QPL shall be submitted for certification. All others will be rejected. Submit four (4) copies of material catalog product numbers and descriptions to the Engineer. One copy of all submittals is to be provided to the maintaining agency. Reference the project number, P.I. number, and QPL number, for the following traffic signal items:

- Signal heads
- LED Signal Modules
- Mounting hardware
- Controllers
- Cabinet assemblies
- Battery Backup System (BBS)
- Detectors
- Monitors (conflict/IVDS)
- Cable
- Load switches
- Blank-out signs
- Lane use signals
- Preformed cabinet bases
- Other related signal equipment (including but not limited to Conduit, Pull boxes, Ground Rods, Enforcement Indications, etc.)

E. Test Results Submittal

Submit the results of the testing of the following items to the Engineer. A copy of the test result submittals shall be provided to the maintaining agency.

- Loop Detector Testing
- Signal Cable Testing
- Interconnect Cable Testing
- Pre-emption Testing
- Controller and Cabinet Testing from Manufacturer (Including conflict monitor)
- Traffic Signal Monitor
- Any other operational testing required by the Engineer

F. Mast Arm Pole Chart

For locations with mast arm pole installations, submit a “Mast Arm Pole Chart” for review and approval by the State Bridge and Structural Design Engineer. The “Mast Arm Pole Chart” shall also include a sketch on an 8 ½ inch x 11 inch (216 mm x 279 mm) sheet of paper showing the following:

- Curb lines
- Location of mast arm pole based on utility information and field location verified by Contractor. (Final location of mast arm pole must meet the criteria for setback from the road as specified in the Roadside Design Guide by AASHTO and in the Standard Detail Drawings.
- Distance from both adjacent curbs to mast arm pole
- Distance along mast arm from pole to curb and from curb to each proposed signal head
- Directional arrow
- Street names
- Position of Luminaries

Label the sketched distances. Once this pole chart is approved, the Contractor shall use the distances measured to the proposed signal head locations when ordering the mast arm to ensure that the mast arm is fabricated with holes for signal head wiring in the correct locations.

647.2 Materials

647.2.01 Delivery, Storage, and Handling

A. State-supplied Equipment

For projects where traffic signal equipment is to be supplied by the Georgia Department of Transportation, obtain State-supplied traffic signal equipment from the Traffic Signal Electrical Facility (TSEF):

1. Contact the Engineer by phone or correspondence within one week after receiving the Notice to Proceed and arrange for a date, time and location to pick up the signal equipment and materials from the Traffic Signal and Electrical Facilities (TSEF).
2. Sign GDOT’s Warehouse Issue Request Form 592 to accept delivery of the State-supplied equipment from GDOT’s Traffic Signal Equipment Warehouse. Initial Form 592 if equipment is received from a GDOT District Field Office.
3. Inspect the equipment to ensure that it is operating properly and perform any operational tests within ten (10) calendar days after receiving the equipment.
4. Before installation, and within ten (10) calendar days, certify to the Engineer in writing that the State-supplied equipment was received in good condition.
5. Notify the Engineer in writing if the State-supplied equipment is defective. The State Signal Engineer will replace the defective State-supplied equipment.
6. If no written dissent is received after ten (10) calendar days or if equipment is installed in the field, the Engineer will consider this equipment to be satisfactory and accepted.
7. The Contractor shall supply new in like and kind State approved equipment to replace State-supplied equipment that is damaged or lost.

B. Signal Equipment

See Section 925 for signal equipment specifications.

The signal equipment, components, supplies, or materials used in traffic signal installation may be sampled and tested if not previously approved by the Department.

Test according to the Specifications and the Sampling, Testing, and Inspection Manual using one or more of the following methods:

- Have the Department use their own facilities.

- Have the supplier or manufacturer use their facilities with an authorized Department representative to witness the testing.
- Provide independent laboratory test results indicating compliance with Department Specifications referenced in Subsection 647.1.02, “Related References”, of this document.
- When testing by the Department is required, supply the item to the Department. Acceptance of materials tested does not exclude further testing or waive warranties and guarantees required by the Specifications.

C. Cable

Use cable conforming to Section 680, Section 922, and Section 925 and the appropriate IMSA, NEMA, or UL Specifications for the wire or cable.

Obtain pole attachment permits required by local utility companies or pole owners to allow joint use for signal cable, hardware, or other auxiliary devices.

D. Interconnect Communications Cable

- 1 Use fiber optic interconnect cable or spread spectrum radio for all new interconnected signal systems. See Section 935 for fiber optic cable or spread spectrum information, specifications, marking and installation and testing techniques.
- 2 Use copper cable only as directed by the Engineer or where specifically shown in the Plans. Refer to Subsection 647.3.05, “Construction”, of this document for installation.

E. Conduit on Structures

Use galvanized rigid steel materials for all exposed conduit for cabling. Use galvanized rigid steel (GRS) conduit on the exterior of signal poles and other structures and to house signal conductors for the entire length from the weather head on the pole to the interior of the cabinet or to the pull box and ground conduit using an approved grounding bushing.(see Subsection 647.3.05V).

647.3 Construction Requirements

Refer to Subsection 107.07 of the Specifications regarding proper conduct of The Work.

647.3.01 Personnel

For the definition of a qualified electrician, see Subsection 755.1.01.

647.3.02 Equipment

Use machinery such as trucks, derricks, bucket vehicles, saws, trenchers, and other equipment necessary for the work and approved by the Engineer prior to installation operations.

647.3.03 Preparation

Utility Permits

A. Application

Apply for, obtain, and pay for utility services and pole attachment permits for signal operation, traffic signal communications including standard telephone service and signal communications as required in the Plans.

B. Maintenance

The Contractor will be responsible for establishing utility services and ongoing monthly costs related to utility services until Final Acceptance of the signal(s) installation, or in the event of multiple installations, the Contractor will be responsible for utility costs until overall project acceptance. After Final Acceptance, the Contractor will provide an orderly transfer these services and permits to the local government or jurisdiction responsible for maintenance and operation. Ensure that the transfer does not interrupt service.

C. Utility Location

1. Adjustment

Prior to ordering signal poles, locate utilities and adjust the location of poles, where necessary, to minimize utility conflicts. Obtain approval from the District Traffic Engineer for any deviation from the Plans.

Determine the final length of mast arms based on any field adjusted pole locations. Final location shall be approved by the District Traffic Engineer.

2. Clearance

When installing aerial cable of any type, it is the Contractor's responsibility to ensure that overhead clearance and separation requirements conform to local utility company standards, the NEC and the NESC. Refer to the Standard Details Drawings for further information on utility clearances.

3. Pre-emption

When traffic signal pre-emption is used, coordinate with the railroad, fire department or any other agency that uses pre-emption to obtain pre-emption output and route output cable to the signal controller operating the intersection to be pre-empted. It is the Contractor's responsibility to obtain all permits and approval for crossing at grade or grade separated railroad facilities.

647.3.04 Fabrication

General Provisions 101 through 150.

647.3.05 Construction

A. Acquiring and Disposing of Equipment

Do not modify the signal equipment, design, and operation without the District Traffic Operations Engineer's written approval.

All traffic signal equipment removed or replaced shall be returned to District Traffic Signal Shops unless otherwise noted in the Plans or as directed by the Engineer or District Signal Engineer. Provide an inventory list and arrange a mutually agreeable delivery time with the District Signal Engineer twenty-four (24) hours in advance. All materials not returned to the District Signal shop shall be the responsibility of the Contractor to remove and dispose.

B. Traffic Signal Equipment Modification and Removal

Upon the Department issuance of Notice to Proceed any existing traffic signal equipment, responsibilities for maintenance, operations and response to traffic signal malfunction become the responsibility of the Contractor and provisions of Subsection 647.3.07, "Contractor Warranty and Maintenance", apply.

1. Remove existing signal equipment that is not used in the final installation when the new signal equipment is operational.

Carefully remove equipment to minimize damage and retain it in its original form. This equipment may include:

- Strain poles including the foundation down to 3 feet (900 mm) below ground level finished grade
- Timber poles
- Traffic signal cabinets including contents, cabinet base and work pads
- Original signal heads including span wire support
- Other equipment not retained in the final installation

Ensure that unused equipment is secured and disposed of in accordance with all Environmental Protection Agency regulations and Department instructions.

2. Replace traffic signal equipment that the District Signal Engineer determines has been damaged or destroyed during installation, modification, or removal of the traffic signal, at no expense to the Department. Replace with new material.
3. If the Engineer finds that the existing material shown in the Plans to be relocated is unsatisfactory, replace with new material. The costs will be paid for as Extra Work.
4. Remove old signal heads by the end of the day that the new signal equipment is placed in operation. Remove all other signal equipment within seven (7) days after operations of the newly installed equipment.

C. Auxiliary Cabinet Equipment

Provide auxiliary cabinet equipment or special purpose equipment with connecting harnesses, if necessary, or as shown in the Plans or Standard Detail Drawings.

1. Install the equipment in its associated cabinet. Extraneous wiring may be necessary to install the equipment. Additional cabling shall be enclosed in NEMA enclosure and neatly secured.
2. Connect the auxiliary equipment to its cable harness, or insert it in premounted racks or sockets.

D. Signal Controllers

Furnish and install approved microprocessor controllers at the locations shown in the Plans or as directed by the Engineer. All equipment furnished shall comply with Section 925, "Traffic Signal Equipment".

1. Identify the controller and other auxiliary equipment by model and revision numbers. These numbers shall agree with previously approved catalog submittals.
2. Assemble the controller, cabinet, and auxiliary equipment to provide the operational sequence shown in the Plans and future operations specified. Ensure the controller functions as a unit with the cabinet assembly.
3. Ensure controller and auxiliary equipment are provided AC power from receptacles marked for controller power.
4. The Department will provide controller firmware. The Contractor shall provide the controller to the Department. The Department will load the firmware into the controller and notify the Contractor that the controller is ready to be picked up. If the controller is purchased with applications firmware, ensure that the firmware provided is the current Department licensed version of firmware including "boot code". Current firmware version shall be at the date of application "turn on".
5. Unless otherwise specified in the Plans or directed by the Engineer, thirty days prior to installation of equipment the Contractor shall deliver the controllers to and pick up the controller from the Traffic Signal Electrical Facility (TSEF) Atlanta office. The Department shall have 30 work days to load the controller firmware starting from the date the Contractor delivered the controllers to the Department.
6. For 2070 signal controllers used for Ramp Metering ensure the Watchdog Timer "Muzzle Jumper" is selected on the field input/output module. This is required for operating with a 208 monitor.

E. Cabinet Assembly

1. Location

The cabinet should be located in accordance with the Plan location, however if the cabinet location needs to be moved, choose a location that:

- a. Protects maintenance personnel from vehicles when servicing the equipment
- b. Allows the front panel door of the controller to open away from the intersection for view of signal indications while servicing or performing cabinet work.
- c. Does not block a sidewalk or passageway and complies with Federal regulations for Americans with Disabilities Act (ADA) clearance requirements.
- d. Is located away from the roadway or curb line to prevent vehicular damage to the cabinet.
- e. Is not located within drainage areas or installed in areas likely to collect and hold surface water.
- f. Relocate the cabinet to avoid conflicts from proposed reconstruction projects, commercial driveways, etc. within the right-of-way at the Engineer's discretion.

2. Erection

Install and level traffic signal controller cabinets at locations shown in the Plans and/or as directed by the Engineer.

- a. Install cabinets to conform to the Standard Detail Drawings. Install pole or base-mounted as indicated in the Plans. Cabinet base shall not extend more than 9 inches above final grade.
- b. Seal base-mounted cabinets to their base using silicone based sealer. Pliable sealant used shall not melt or run at temperatures as high as 212 °F (100 °C).
- c. Use prefabricated bases and work pads

- d. Install technician pad in front and rear of the controller cabinet door and if applicable in front of battery backup cabinet door. See Standard Details for pad information.
- e. Close all unused conduit in the controller base with a PVC cap sized appropriately. Do not permanently affix the conduit cap to the conduit. Seal those conduits used for signal cable with a pliable sealant to prevent moisture and insects from entering the cabinet via the conduit.

3. Field Cabinet Wiring

All wiring shall be neat and secured and comply with NEC, NEMA, and Table 647-1, Table 647-2, Table 647-3 Table 647-4, Table 647-5, and Table 647-6 of this Specification.

- a. Cut field cabinet wiring to the proper length and organize it in the cabinet. Wire lengths should be slack (minimum 10 feet) allowing for future modifications.
 - Use at least No. 6 AWG wire for the conductors between service drop and AC+ and the AC- terminals.
- b. Do not mount electrical meter to the cabinet. Submit "power pedestal" or other method of providing location for mounting to the Engineer.
- c. Label all field terminals and conductors so as to identify the specific field input.
- d. Crimp terminal connections to conductors with a ratchet-type crimping tool that will not release until the crimping operation is completed.
- e. Do not use splices inside the controller cabinet, base, or conduit.
- f. Do not use solid wire, except grounding wire.
- g. Supply the cabinets with cabinet wiring diagrams, schematic drawings, pin assignment charts, and manuals for circuits and components. Store these documents in the cabinet in a resealable, weatherproof container.

F. Signal Monitors

Furnish signal monitor equipment as follows,

1. Mount signal monitors in a rack with appropriate connectors to attach to the wiring harness.
2. Program the monitor according to the signal operation indicated in the Signal Plans before placing the installation in flash or stop-and-go operation. Provide any signal monitoring programming tools required to program the monitor to the maintaining agency.
3. Configure and equip the signal monitor to monitor all red signal indications. Ensure that the red output for unused or vacant load bays or output slots is jumpered to 120 V AC+.
4. For ITS Cabinets configure the CMU and AMU.
5. For Ramp Metering Cabinets mount model 208 monitor in rack and provide the necessary programming required for the Ramp Meter operation as shown in the Plans.

G. Power Disconnect

Install a power disconnect box at each intersection as shown in the Standard Detail Sheets. Ensure the power disconnect is installed at the top of the cabinet pole or as indicated on plans. Install service cables from disconnect box and terminate as specified on the controller cabinet-wiring or battery backup diagram.

H. Flashing Beacon

Furnish and install the flashing beacon controller at the locations shown in the Plans and/or as directed by the Engineer. Install it as a complete unit (solid state flasher and cabinet with time clock, if applicable) and ensure that it conforms to this Specification.

I. Loop Detector Systems

Install and test loop detector systems according to NEMA Standards Publication TS 1-1983, Section 15, Inductive Loop Detectors, subsequent revisions (except as shown in the Plans), Details, notes, and this Specification.

Ensure that loop detectors are complete and fully operational before placing the signal in stop-and-go operation.

1. General Installation Requirements

Each loop must consist of at least two turns of conductor, unless otherwise shown in the Plans or this Specification. Do not place a portion of the loop within 3 feet (1 m) of a conductive material in the pavement such as manhole covers, water valves, grates, etc.

- a. Install pull boxes, condulets, and conduits before beginning loop installation.
- b. Ensure that the ambient pavement surface temperature in the shade is at least 40 °F (5 °C) before cutting roadway and placing sealant into saw cuts.

2. Loop Saw Cuts

- a. Outline the loop on the pavement to conform to the specified configuration.
- b. Ensure each loop has a separate saw cut with a minimum distance between saw cuts of 6 inches.
- c. Install the detector loop in a sawed slot in the roadway surface deep enough to provide at least 3 inches (76 mm) of sealant cover.
- d. Ensure that the slot is at least 0.25 inches (6 mm) wide for stranded No. 14 AWG loop wire, THWN, XHHW, or XLPE, and at least 0.31 inches (7 mm) wide for polyethylene or PVC encased No. 14 AWG loop wire.
 - 1) At the intersection of the slots, drill a 2 inch (51 mm) diameter hole or make miter saw cuts in the pavement. Overlap miter saw cuts at the intersection of saw cuts so that the slots have a full-depth and smooth bottom.
 - 2) Prevent the wire from bending sharply.
 - 3) Do not install detector loop wire unless sawed slots are completely dry and free of debris. Pressure wash the slot to guarantee adhesion of the loop sealant. Use compressed air to thoroughly dry the sawed slot.
 - 4) Install the loop wire starting at the nearest pull box or condulet, around the loop for the specified number of turns, and back to the pull box or condulet.

NOTE: Loop wire from the street is to be spliced in condulets or pull boxes only.

- 5) Refer to table 647-9 for the number of turns for Quadrupole loops. Refer to table 647-8 for the number of turns for) Bipole loops. Bipole loops require at least three (3) turns.
- e. Press the wire in the slot without using sharp objects that may damage the jacket.
- f. Hold the loop in place every 5 feet (1.5 m) with 1 inch (25 mm) strips of rubber, neoprene, flexible tubing, or foam backer rod as approved by the Engineer.
- g. Leave the hold down strips in place when filling the slot with loop sealant.
- h. Where encased loop wire is used, apply a waterproof seal to the ends of the polyethylene tubing that encase the wire to prevent moisture from entering the tube.
- i. Where the loop wires cross pavement joints and cracks, protect the loop wires using the method specified in "Traffic Signal Details" in the Plans. When crossing expansion joints drill a 2 inch diameter hole minimum 3 inches deep, or to bottom of saw cut. Do not install loop wires in an expansion joint.
- j. Twist Loop Lead-in 3 turns per foot.

3. Loop Sealing

After successfully testing each loop, fill the slots with sealant to fully encase the conductors.

- a. Seal the slot within one hour of cutting slot.
- b. Ensure that the sealant is at least 3 inches (75 mm) thick above the top conductor in the saw cut.
- c. Apply the sealant so that subsequent expansion does not extend the sealant material above the pavement surface.
- d. In case of accidental spill, before the sealant sets, remove surplus sealant from the adjacent road surfaces without using solvents or epoxy sealants.
- e. When the Engineer determines that the loop sealant can accommodate traffic but the surface is tacky, dust the sealer on the pavement surface with cement dust before opening the roadway to traffic.
- f. Dispose of the solvents used to clean loop installation equipment according to the manufacturer's specifications and local, State, and Federal regulations.

4. Loop Connections

Connect loop conductors to a shielded lead-in cable that runs from the pull box adjacent the pavement edge or conduit to the detector hook-up panel in the controller cabinet, unless otherwise specified in the Plans.

- a. Use continuous (no splices) shielded lead-in cable from the pull box or conduit to the cabinet input file terminal. Do not ground the shield in the loop lead-in cable at the cabinet.
- b. Connect each loop to an individual detector channel as specified in the Plans.
- c. If the Plans specify that two or more loops will be operated on the same detector channel or detector amplifier unit, wire them in series to their loop lead-in at the pull box or conduit.
- d. Use series-parallel connections when series connections do not meet the manufacturer's specified operating range for the detector amplifier unit.
- e. Make weather-tight and waterproof splices as detailed on the Plan Standard Detail Sheets. Make loop splices to loop lead-in cable only after the detector system has been tested and demonstrated under traffic conditions to the Engineer's satisfaction.

5. Loop Maintenance

Locate all existing loops, determine the operational status of all loop assemblies, and notify the Engineer prior to commencing loop construction activities at the intersection.

Maintain all existing, operational loops, unless otherwise notified by the Engineer. Repair of an existing loop that is non-operational prior to beginning work will be considered as extra work.

Locate points of conflict between new loops and existing loops, and install all new loops and saw cuts so as not to cut existing loop lead-ins and loop wires that are to be retained.

If an existing operational loop that is not scheduled for replacement fails during the construction time frame, notify the Engineer and complete the replacement of the damaged loops immediately.

The Engineer may grant a twenty-four (24) hour period to repair the loops if their operation is not critical. All costs associated with the replacement of the loops damaged during construction shall be charged and paid for by the Contractor.

J. Pedestrian Push Button

Install the push button with a pedestrian instruction sign as illustrated on the Department's Standard Detail Sheets and according to the Plans.

1. Place the pedestrian buttons as shown on the Signal Plan Sheet and within 10 inches (254 mm) of sidewalk or concrete landing pad. Position the pedestrian button to correspond to the appropriate signal phase. Locate pedestrian buttons perpendicular to the appropriate signal indication and signal phase, and as field conditions require.
2. Place the center of the buttons between 38 inches (0.965 m) and 42 inches (1.05 m) above the sidewalk or ground level.
3. Seal all openings to prevent moisture from entering the pushbutton.

K. Cable

Install and connect electrical cable to the proper equipment to produce an operating traffic signal system. Use stranded copper cable conforming to Section 925.

Install wiring in accordance with IMSA, NEMA, UL, and the Department's Traffic Signal Wiring Standards, shown in Tables 647-1, 647-2, 647-3, 647-4, 647-5, and 647-6 of this Specification.

In addition to the information provided below, see Section 682, Section 922, and Section 925 for cable equipment and installation specifications.

Table 647-1 Vehicular Signals Georgia DOT Wiring Standards

Signal Indications	Four Conductor Cable		Seven Conductor Cable		Ten Conductor Cable	
	Phases 2, 4, 6, & 8	Phases 1, 3, 5, & 7	Phases 2, 4, 6, & 8	Phases 1, 3, 5, & 7	Phases 2, 4, 6, & 8	Phases 1, 3, 5, & 7
Red	Red Wire		Red Wire		Red Wire	
Yellow	Black Wire		Orange Wire		Orange Wire	
Green	Green Wire		Green Wire		Green Wire	
Red Arrow		Red Wire		White Wire with Black Tracker		Red Wire with Black Tracker
Yellow Arrow		Black Wire		Black Wire		Orange Wire with Black Tracker
Flashing Yellow Arrow		Green Wire		Orange Wire		Blue Wire
Green Arrow		Green Wire		Blue Wire		Green Wire with Black Tracker
Auxiliary					Black Wire	Black Wire
Neutral	White Wire	White Wire	White Wire	White Wire	White Wire	White Wire
Spare					White Wire with Black Tracker	White Wire with Black Tracker

Table 647-2 Vehicular Loop Detectors Georgia DOT Wiring Standards

Detectors	Phases 3, 4, 7, and 8 Presence Loops		Phases 2 and 6 Setback Pulse Loops and Phases 1 and 5 Presence Loops	
	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair
Right Curb Lane	Red Wire	Red/Black Pair (1)	Red Wire	Red/Black Pair (1)
Second Lane	Green Wire	Green Black Pair (1)	Green Wire	Green Black Pair (1)
Third Lane	White Wire	White/Black Pair (1)	White Wire	White/Black Pair (1)
Fourth Lane	Red Wire	Red/Black Pair (2)	Red Wire	Red/Black Pair (2)
Fifth Lane	Green Wire	Green/Black Pair (2)	Green Wire	Green/Black Pair (2)
Sixth Lane	White Wire	White/Black Pair (2)		

First Left-Turn Lane			Red Wire	Red/Black Pair (3)
Second Left-Turn Lane			Green Wire	Green/Black Pair (3)

Table 647-3 Pedestrian Signals Georgia DOT Wiring Standards				
Signal Indications	Four Conductor Cable		Seven and Ten Conductor Cable	
	Phases 2 and 6	Phases 4 and 8	Phases 2 and 6	Phases 4 and 8
Don't Walk	Red Wire	Red Wire	Red Wire	Orange Wire
Walk	Green Wire	Green Wire	Green Wire	Blue Wire
Neutral	White Wire	White Wire	White Wire	White Wire

Table 647-4 Pedestrian Detectors Georgia DOT Wiring Standards		
Push Buttons	3 Pair Shielded Cable	
	Phase 2 and 6	Phase 4 and 8
Call	Green and Black Pair	Red and Black Pair

NOTE: Do not use aluminum cable.

Table 647-5 Ramp Meter Signals Georgia DOT Wiring Standards	
Signal Indications	3-Section Signal Heads Seven Conductor Cable L1,L2,L3
Red	Red Wire
Yellow	Orange Wire
Green	Blue Wire
Neutral	White Wire

Table 647-6 Ramp Meter Loop Detectors Georgia DOT Wiring Standards

	Demand Detector Loops		Queue Detector Loops	
	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair
Lane 1	Red Wire	Red/Black Pair (2)	Red Wire	Red/Black Pair (1)
Lane 2	Green/Wire	Green Black Pair (2)	Green Wire	Green/Black Pair (1)
Lane 3	White Wire	White/Black Pair (2)	White Wire	White/Black Pair (1)
	Passage Detector Loops		Mainline Detector Loops (if used)	
	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair
Lane 1	Red Wire	Red/Black Pair (3)	Red Wire	Red/Black Pair (4)
Lane 2	Green Wire	Green/Black Pair (3)	Green Wire	Green/Black Pair (4)
Lane 3	White Wire	White/Black Pair (3)	White Wire	White/Black Pair (4)

L. Signal Cable for Vehicular Signal Heads and Pedestrian Heads

Install cable for signal heads and pedestrian heads as follows:

1. For vehicle signal heads, install one 7-conductor or 10-conductor signal cable for each intersection approach from the controller cabinet to the through-signal head on each approach as directed by the Engineer. From this leftmost signal head, install a 7-conductor or 10-conductor signal cable to each of the other signal heads on the same approach in sequence. If a flashing yellow arrow signal head is used for the left turn display, install either a second 7-conductor signal cable per left turn phase or one 10-conductor signal cable for each intersection approach.
2. For pedestrian signal heads, install one 4-conductor or 7-conductor signal cable from the controller cabinet to each pedestrian head installation location to operate either one or two pedestrian heads.
3. Make a minimum 1 foot (300 mm) diameter 3 turn weather drip loop as shown in the Standard Detail Drawings in the Plans at the entrance to each signal head.
4. Neatly tie signal cables leaving a structure or weatherhead to enter a signal fixture. Tie the cables to the messenger cable as illustrated in the Standard Detail Drawings.
5. For Ramp Meter signal heads install one 7-conductor signal cable for each lane of the Ramp Meter operation from the controller cabinet.

M. Interconnect Communications Cable

Use fiber optic interconnect cable as specified in the Plans for all new interconnected signal systems. See Section 935 for fiber optic cable information, specifications and installation and testing techniques, and all other signal interconnect methods. Install interconnect communications cable as follows:

1. Provide support for the interconnect cable on new or existing utility poles or signal poles; install underground in conduit.
2. Use fiber optic standoff brackets as needed to prevent damage from poles, trees and other structures.
3. Pull cables with a cable grip that firmly holds the exterior covering of the cable.
4. Pull the cables without dragging them on the ground, pavement or over or around obstructions. The Engineer will inspect and approve the cable prior to installation. Use powdered soapstone, talc, or other approved inert lubricants to pull the cable through the conduit.
5. When using a separate messenger cable, spirally wrap the communications cable with a lashing machine according to the IMSA-20-2 Specifications.
6. Do not splice outside the signal cabinet except at the end of full reels of 5,000 feet (1500 m).
7. Ensure that splice points are near support poles and accessible without closing traffic lanes.
8. Unless drop cable assemblies for communications are used, loop the cable in and out of the control cabinets. Coil and tie 10 feet (3 m) of cable in the controller cabinet foundation. Tape the cable ends to keep moisture out until the terminals are attached.
9. Prevent damage to the cable during storage and installation.

NOTE: Do not allow anyone to step on or run over any cable with vehicles or equipment.

N. Loop Detector Lead-in Cable

Use 3-pair shielded lead-in cable in compliance with Section 925 and manufacturer's recommendations for Detector loop lead-in installed for loop detectors. Ensure the three pair has 3 separate distinguishing colors. Use a shielded lead-in cable connecting the loop to the detector hook-up panel in the controller cabinet, unless otherwise specified in the Plans. Provide a separate 3- pair for each phase or future phase.

1. Splice the loop detector wire to a shielded loop detector lead-in cable in a pull box adjacent to the loop detector installation.

2. Use continuous (no splices) shielded lead-in cable from the pull box or conduit to the cabinet input file terminal. If induced voltage is present, the shield in the loop lead-in cable shall be grounded to cabinet per NEC. Otherwise do not ground the shield in the loop lead-in cable at the cabinet.
3. Connect each loop to an individual detector channel as specified in the Plans.
4. Each detection loop shall be connected to the control cabinet via separate lead-in pair.
5. Set back loops with aerial loop leads to the control cabinet shall be supported by ¼ inch messenger cable with no splices between the control cabinet and the initial point of aerial attachment.
6. Make weather tight and waterproof splices between lead-in and loop wire. Loop installation may be approved only after the detector system has been tested and demonstrated under traffic conditions to the Engineer's satisfaction, during the Operational Test Period.

O. Pedestrian Push Button Lead-in

Use 3-pair shielded lead-in cable compliant with Section 925 for pedestrian push buttons. Install one 3-pair shielded lead-in cable to each pedestrian push button station(s) location to operate either one or two push buttons. Do not ground the shield for the push button lead-in cable at the controller cabinet. Do not use the same 3 pair cable for loop and pedestrian detectors.

P. Messenger Cable, Stranded-Steel

The messenger is used to support signal cable indicated in the Plans as overhead cable. Use devices such as aluminum wrap, aluminum wire ties or lashings to attach the cable.

- Before erecting the messenger strand, determine the suspension strand length to span the distance between the poles.
- Run the messenger strand from structure to structure without splicing.
- The minimum allowable sag is two and one-half percent (2.5%) for timber poles, five (5%) for strain poles of the longest diagonal distance between the signal poles unless pole manufacturers specifications exceed 2.5%. The contractor is responsible for providing the District Signal Engineer with sag calculations for new installations.
- Calculate attachment points for the messenger strand at the signal pole according to the Plan Detail Sheet.

Set messenger strands so that the height conforms to the clearances on the Standard Detail Drawings. Attach cables to messenger cable using lashing wire, aluminum ties, or lashing rods (Subsection 925.2.43). If lashing rods are used use lashing rods sized for the cables and messenger strand. Only use lashing rods that are of the same material as the messenger strand. Lashing wire shall only be used to support aerial loop lead-in and fiber optic.

1. Drill wood poles to receive the eye bolts so that the span wire and eyebolt at each connection form a straight angle.
2. Never pull or strain the messenger on the eye bolt to an angle of variance greater than ten degrees (10°).
3. Attach down guy wires to guy hooks. Use a minimum 3/8 inch messenger cable for down guys. Never attach them directly to the eye of an eyebolt.
4. Ensure that messenger strand clearances conform with local utility company Standards.
5. Make stranded messenger cable attachment points with the appropriate size strand vises or 3 bolt clamps. Stranded steel messenger cable is not paid for separately under this Specification.
6. Use minimum ¼ inch messenger cable.
7. Use standoff brackets as needed to prevent damage from poles, trees or other structures.

NOTE: Never splice messenger cable between structures or stand off brackets.

Q. Underground Cable for Signal Circuits

Underground cable for signal circuits includes cable, with conduit, as shown in the Plans. Install cable under existing pavement or surfaced shoulder, according to Subsection 680.3.05.

1. Cable in Conduit

Pull cable into conduits as follows:

- a. Pull cables into conduits without electrical or mechanical damage. Pull cables by hand only. The use of trucks or other equipment is not permitted, unless approved by the Engineer. If mechanical pulling is approved, do not exceed the manufacturer's tension rating for the cable.
- b. Pull cables with a cable grip that firmly holds the exterior covering of the cable.
- c. Use powdered soapstone, talc, or other inert lubricants to place conductors in conduit according to manufacturer's recommendations.
- d. Handle and install the conductors to prevent kinks, bends, or other distortion that may damage the conductor or outer covering.
- e. Pull all cables in a single conduit at the same time. When pulling cables through hand holes, pole shafts, etc., use a pad of firm rubber or other material between the cable and the opening edges to prevent cable damage.
- f. When installing cable in conduit with existing signal cable circuits remove all existing cables and pull them back into the conduit with the new cables.
- g. The distance between pull boxes in a run of conduit shall not be greater than 100 feet (30 m), unless otherwise shown in the Plans or approved by the Engineer or District Signal Engineer, with the exception of fiber optic cable.
- h. The distance between pull boxes in a run of conduit for fiber optic cable shall not exceed 750 feet (225 m), unless otherwise shown in the Plans or approved by the Engineer. Identification tape and tone detection wire shall be used for fiber optic cable in conduit. All unused conduit shall have a continuous pull cable installed between pull boxes.

2. Splices

Required splicing shall be performed according to the National Electric Code; use materials compatible with the sheath and insulation of the cable.

Insulate required splices with electrical insulation putty tape, plastic, pressure sensitive, all-weather 1.5 mil (0.038 mm) electrical tape in accordance to standard details.

- a. Make the spliced joints watertight.

Note: Splice detector wires to shielded loop detector lead-in at pull boxes located immediately after the loop wire leaves the roadway. No splices will be permitted in shielded loop detector lead-in cable from this point to the controller cabinet.

R. Conduit and Fittings

Install conduit by type (GRS, HDPE, PVC) as shown in the Plans and the Standard Detail Drawings. Refer to the NEC, for conduit full percentages.

Separate the power cable to the controller cabinet from all other cables in its own 1 in (25 mm) galvanized rigid steel conduit except inside poles. Ensure that conduit conforms to Section 682, Section 923 and Section 925 with the following addition:

- Use flexible conduit only where shown in the Details or as directed to do so in writing by the District Signal Engineer.

Use the conduit size specified in the Plans, unless otherwise directed by the Engineer. Obtain written approval from the Engineer prior to installing conduit other than the size specified in the Plans.

All 2 inch (50 mm) conduit elbows shall be "sweep" type. The minimum radius for the elbow is 18 inches (450 mm), unless otherwise approved by the Engineer.

NOTE: Do not use multi-cell conduit.

Install conduit and fittings as follows:

1. Ensure that exposed conduit on poles are galvanized rigid steel (GRS) conduit.
2. Ream the ends of metallic conduit after cutting the threads. Ream other conduit as necessary.
3. Cut the ends square, and butt them solidly in the joints to form a smooth raceway for cables.
4. Make conduit joints to form a watertight seal.
5. Coat metallic conduit threads with red- or white-lead pipe compound, thermoplastic or Teflon seal. Ensure that they are securely connected.
6. Make plastic conduit joints with materials recommended by the conduit manufacturer.
7. Install bushings in the conduit to protect the conductors. When conduit is installed for future use, properly thread and cap the ends of the metallic conduit runs.
 - a. Plug the ends of nonmetallic conduit runs to prevent water or other foreign matter from entering the conduit system.
 - b. Seal the exposed conduit ends with a permanently malleable material.
 - c. Ensure that empty conduit installed for future wire or cable has a nylon pull string or cord inside that is impervious to moisture and rot and can withstand a load of 50 pounds (23 kg) without breaking. Secure this pull cord at each open end and at each pull box.
8. Ensure that conduit on pole exteriors are mounted with galvanized, two-hole straps or clamps. Place the clamps not more than 3 feet (1 m) from junction boxes, condulets, or weatherheads. Place it at 3 foot (0.9 m) intervals elsewhere.
 - a. Fasten the clamps to wood poles with galvanized screws or lag bolts.
 - b. Do not install conduit risers on concrete, steel, or mast arm poles unless approved by the Engineer.
9. Install a weatherhead at the end of exterior conduit runs on a pole or other structure to prevent moisture or other matter from entering the conduit.
10. After installation, ensure that the conduit or fitting placement has not warped or distorted any conduit, terminal, control or junction box.
11. Ensure Conduit that is terminated at poles is grounded at the pull box.

S. Underground Conduit

Underground conduit includes encased or direct burial conduit.

1. Install the conduit in a trench excavated to the dimensions and lines specified in the Plans.
 - a. Provide at least 18 inches (450 mm) finished cover, unless otherwise specified.
 - b. Under pavement, excavate at least 36 inches (900 mm) below the bottom of the pavement.
2. Before excavation, the Contractor is responsible for determining the location of electrical lines, drainage, or utility facilities in the area to prevent damage.
 - a. Place the conduit where it will not conflict with proposed guardrail, sign posts, etc.
 - b. Change locations of conduit runs, pull boxes, etc., if obstructions are encountered during excavation. Changes are subject to the Engineer's approval.
 - c. Where possible, provide at least 12 inches (300 mm) between the finished lines of the conduit runs and utility facilities such as gas lines, water mains, and other underground facilities not associated with the electrical system.
3. When the conduit run is adjacent to concrete walls, piers, footings, etc. maintain at least 4 inches (100 mm) of undisturbed earth or firmly compacted soil between the conduit and adjacent concrete or, when the conduit is encased, between the encasement and the adjacent concrete. Unless specified in the Plans, do not excavate trenches in existing pavement or surfaced shoulders to install conduit.
4. When placing conduit under an existing pavement, install the conduit by directional boring, or other approved means. See Section 682 for directional boring pipe specifications. Obtain the Engineer's approval prior to installing conduit by means of boring-method.

5. When the Plans allow trench excavation through an existing pavement or surfaced shoulder, restore the pavement shoulder surface, base, and subgrade according to the Specification.
6. Cut trenches for conduit on a slight grade (0.25 percent minimum) for drainage, unless otherwise specified. When the grade cannot be maintained all one way, grade the duct lines from the center, both directions, down to the ends.
7. Avoid moisture pockets or traps. Excavate vertical trench walls.
8. Tamp the bottom of the trench to produce a firm foundation for the conduit.
9. When necessary to prevent damage, sheet and brace the trenches and support pipe and other structures exposed in the trenches.
10. Conduit installed for fiber optic cable installation shall have identification tape and detectable tone wire installed for detection as specified and detailed in the Project Standard Detail Sheets.
11. Install direct burial conduit as shown in the Plans. Use rigid galvanized steel, or polyethylene conduit. Excavate at least 36 inches (900 mm) below the top of the finished ground or 36 inches (900 mm) below the bottom of the pavement.
12. When rock is in the bottom of the trench, install the conduit on a bed of compacted, fine-grain soil at least 4 inches (100 mm) thick.
13. Conduit installed for fiber optic cable installation shall have detectable tone wire installed for detection as specified in Section 682 and detailed in Standard Detail Sheets.

T. Encased Conduit

Place encased conduit in the locations shown in the Plans unless otherwise specified. Construct as follows:

1. Construct the encasement using Class A concrete that meets requirements in Section 500 .
2. Extend the encasement or conduit under roadway pavements or surfaces 6 inches (150 mm) past the outer edge of paved shoulders or sidewalks, or past curbs if no shoulder or sidewalk is present.
3. Extend the conduit at least 3 inches (75 mm) beyond the encasement.
4. Place 3 inches (75 mm) of concrete in the bottom of the trench and place the conduit on top of it.
5. Temporarily plug the ends of the conduit to prevent concrete or foreign materials from entering.
6. Cover the conduit with at least 3 inches (75 mm) of concrete. Wait to encase the conduit with concrete until the Engineer inspects and approves the conduit.
7. Cure the concrete encasement according to Subsection 500.3.05.Z, except curing may be reduced to twenty-four (24) hours. Use a precast encasement if approved by the Engineer.

U. Backfilling

Immediately backfill the conduit after the Engineer's inspection and approval, except for encased conduit, which must complete a twenty-four (24) hour cure period.

1. Backfill with approved material free of rocks or other foreign matter.
2. Backfill in layers no greater than 6 inches (150 mm) loose depth, up to the original ground level.
3. Compact each layer to one hundred percent (100%) of the maximum laboratory dry density as determined by GDT 7, GDT 24a, GDT 24b, or GDT 67 whichever applies.-

V. Conduit on Structures

Install conduits, condulets, hangers, expansion fittings, and accessories on structures according to the Plans and, unless otherwise specified, the following:

1. Run the conduit parallel to beams, trusses, supports, pier caps, etc.
2. Install horizontal runs on a slight grade without forming low spots so they may drain properly.
3. Run conduits with smooth, easy bends. Hold the conduit ends in boxes with locknuts and bushings to protect the conductors.
4. When not specified in the Plans or Special Provisions, submit the type and method for attachment to structures to the Engineer for submission to the District Signal Engineer for approval.

5. Ground galvanized rigid steel conduit in pull boxes.

All exposed conduit shall be galvanized, rigid conduit unless otherwise specified.

W. Testing Conduit

After installing the conduit, test it in the presence of the Engineer.

1. Test conduit using a mandrel 2 inches (50 mm) long and 0.25 inches (6 mm) smaller in diameter than the conduit.
2. Repair conduit to the Engineer's satisfaction if the mandrel cannot pass through. If repairs are ineffective, remove and replace the conduit at no additional cost to the Department.
3. Thoroughly clean the conduits. When installing conduit but wiring at a later date:
 - a. Perform the mandrel test.
 - b. Ream the duct opening to remove burrs or foreign matter.
 - c. Thoroughly clean the duct.
 - d. Provide and install a weatherproof cap at each open end.
 - e. All installed conduit not used or containing cable shall have a continuous nylon pull string installed between junction boxes.

X. Grounding

Ground the cabinets, controller, poles, pull boxes, and conduit to reduce extraneous voltage to protect personnel or equipment.

NOTE: Grounding shall meet the minimum requirements of the NEC.

Provide permanent and continuous grounding circuits with a current-carrying capacity high enough and an impedance low enough to limit the potential above the ground to a safe level.

Perform grounding as follows:

1. Bond the grounding circuits to nonferrous metal driven electrodes. Use electrodes that are at least 0.625 inches (15 mm) in diameter, 8 feet (2.4 m) long, and are driven straight into the ground.
2. Use the shortest possible ground lead that leads directly to a grounding source.
3. Ensure that the maximum resistance between the ground electrode and the earth ground is no greater than twenty five (25) ohms.
4. Connect the ground electrodes and the ground wire with an exothermic weld or ground rod clamp as approved by Signal Engineer.
5. Connect neutral conductors to the cabinet buss-bar and ground them at each terminal point.
6. Ground the cabinet with a No. 6 AWG solid copper wire between the buss-bar to the ground electrode. Bends shall not exceed 4 inch (100 mm) radius bends.
7. Permanently ground the poles by bonding the No. 6 AWG solid copper wire to a separate ground rod.
8. Ground pole-mounted accessories to the pole.
9. Underground metallic conduit or down guys are not acceptable ground electrodes. Do not use Snap-On connections.
10. For extended distances between Ramp Meter and IVDS additional grounding may be required by the manufacturer.

Y. Ground Rod

Install copper clad ground rods adjacent to the traffic signal pole bases, controller cabinet bases, and in pull boxes to shield and protect the grounding system.

When ground rods are not protected, bury them at least 2 inches (50 mm) below the finished ground level.

1. Use 0.625 inch (15 mm) diameter ground rods at least 8 feet (2.4 m) long. Use copper clad ground rods.
2. Drive single ground rods vertically until the top of the rod is no more than 2 inches (50 mm) above the finished ground.

3. Attach a length of No. 6 AWG solid copper wire to the top of the ground rod using an exothermic weld.
4. When controller cabinets are mounted on timber poles, ground them with No. 6 AWG solid copper wire attached to the ground rod. Run the wire inside a minimum 0.75 inch (19 mm) rigid conduit attached to the timber pole and to the chassis ground in the controller cabinet.
5. When ground penetration is not obtained:
 - a. Place a horizontal ground rod system of three (3) or more parallel ground rods at least 6 feet (1.8 m) center-to-center and 30 inches (720 mm) below the finished ground.
 - b. Ensure that this grounding system produces a resistance of 25 ohms or less.
 - c. Join the ground rods and connect them to the grounding buss of the traffic signal cabinet with No. 6 AWG solid copper wire.
6. Install a ground wire on wood poles.
 - a. Use at least No. 6 AWG solid copper wire bonded to the grounding electrode and extending upward to a point perpendicular to the uppermost span.
 - b. Place wire staples no greater than 2 feet (0.6 m) apart to secure the ground wire to the pole.
 - c. Connect the span wire to the pole ground using copper split bolt connectors. Provide a separate ground rod for pole mount cabinets. Do not use the pole ground. Bond the pole ground to the pole cabinet ground rod.
7. Ensure that grounding for signal strain poles conforms to the grounding assembly typical erection Detail Sheet in the Plans.
8. Permanently ground cabinet and cabinet conduits to a multi-terminal main ground buss.
 - a. Use a No. 6 AWG solid copper wire bonded between the buss and grounding electrode.
 - b. Connect the power company neutral, conduit ground, and grounds of equipment housed in the cabinet to the buss-bar.
 - c. Do not ground to a permanent water system instead of the driven ground rod. Ensure that grounding devices conform to the requirements of the NEC and NEMA.
9. When testing for resistance ensure the ground is dry. The Contractor is responsible for submitting the ground test results.

Z. Signal Poles

See Section 501 for signal pole materials certification and Subsection 925.2.27, Subsection 925.2.28, Subsection 925.2.29, Subsection 925.2.30 and Subsection 925.2.31 for traffic signal equipment. Refer to the Plans for pole locations.

Where necessary, adjust pole location to avoid utility conflicts. Provide minimum clearance distances between the signal pole and the roadway as specified in the Plans and on the Standard Detail Drawings.

1. Strain Poles

Provide signal strain poles that conform to Section 639.

Provide caissons or foundations that conform to the "Construction Detail for Strain Pole and Mast Arm Pole Foundations" in the Plans.

Determine the required foundation size based on the manufacturer's specified "bending moment at yield" for each pole.

Provide strain poles with manufacturer-installed holes for pedestrian heads and push buttons. Seal unused holes with water tight plugs that match the pole finish provided by the manufacturer of the pole. All steel strain pole holes that are used shall have a rubber grommet or weather head.

Rake the poles during installation to provide a pole that is plumb once the load is applied.

2. Metal Poles

Install metal poles as follows:

- a. Ensure that anchor bolts, reinforcing bars, and ground rods conform to Section 639 and Section 852 and are placed in the excavation.

- b. Support the anchor bolts with a template to provide the proper bolt circle for the pedestal or pole to be installed. Anchor bolts shall be installed without any modifications. Refer to signal details for proper installation.
- c. Wire the reinforcing bars together or to the anchor bolts.
- d. Wire the conduits in the base to the reinforcing bars for support. Ensure that they are accessible above and beyond the foundation.
- e. Before pouring the foundation concrete, determine that the anchor bolt orientation is correct so that the tensile load is divided between at least two anchor bolts. Pour and vibrate the concrete with the Engineer present.
- f. Ensure that the pole foundations and pedestals with the anchor-type base conform to Section 500 and Section 639. Do not install or locate poles without the Engineer's approval. Ensure the foundation meets AASHTO guidelines.
 - 1) The Engineer may take a concrete test cylinder as it is being poured.
 - 2) Cure the cylinder and submit it for testing to the Office of Materials and Research.
- g. If the concrete foundation fails to meet the requirements of the Specifications and is not accepted, replace the foundation upon notification of failure.
- h. After installing poles and applying the load of the signal span, inspect them for plumb and for the proper horizontal position of the mast arm, when applicable. Make sure all threads of the nut are threaded onto the anchor bolt.
- i. Correct deficiencies by using the leveling nuts on the anchor bolts or by adjusting the mast arm.
- j. The Engineer will examine the pedestals and poles for damaged paint or galvanizing. Restore the finish coating where necessary.
- k. After the Engineer approves the pole installation, provide an acceptable method of protecting the area between the pole base and the top of the foundation to prevent the accumulation of debris.

If the finish or galvanized steel materials is scratched, chipped, or damaged, the material will be rejected. The finish may be replaced as specified under Section 645, with the Engineer's approval.
- l. For poles or arms that need galvanization, thoroughly clean the steel poles and arms and touch up non-galvanized parts with i-d red or original-type primer.
- m. Apply the remaining coats according to the System V (Heavy Exposure) Section 535, unless otherwise indicated in the Plans. The entire pole shall be the same color.
- n. Install a service bracket and insulator on one pole at each intersection to attach power service wire as specified in the Plan Details. Install a disconnect box on the cabinet pole at each intersection to attach power service where the power service is provided overhead.
- o. Install poles to which controller cabinets are attached with mounting plates, bolts, nipples, and at least two, 2.5 inch (64 mm) threaded openings at the top and at least two (2) 2 inch (50 mm) at the bottom of the pole.
- p. Attach the fittings to the poles as specified by the manufacturer in the Plans or as the Engineer directs. The fittings may include:
 - Cast aluminum cap
 - Pole clamp hardware for span wire attachment
 - Weatherhead with chase nipples and couplings
 - Galvanized elbow with bushing installed by cutting the pole and welding in place around the entire circumference
- q. The Office of Materials and Research will inspect the anchor bolts. If approved, the Office of Materials and Research will display the inspector's hammer stamp mark on the top of the bolt.

NOTE: Never add holes or openings to the metal pole or mast arm without approval from the Office of Bridge and Structural Design.

3. Concrete Strain Poles

- a. Ensure that concrete strain poles meet the requirements of Section 639 and detailed construction drawings.

- b. Install concrete strain poles so that the angle of variance between the eye bolt on the pole and the span wire is less than ten degrees (10°).
- c. Verify pole hole orientations for pedestrian heads, pedestrian push button stations, luminaries arms, etc., with the Engineer prior to proceeding with traffic signal installation. For poles at cabinet location provide at least two 2.5 inch (64 mm) openings at the top of pole and at least two 2.0 inch (50 mm) threaded openings at the bottom.
- d. Plug all unused holes. Use Grout or threaded fittings. Match the finish of the pole.

4. Mast Arms

Install mast arms that can accommodate traffic signal mounting hardware and that adhere to the manufacturer's recommended procedures and Section 925 and Section 915. Do not add holes.

- a. Seal the openings in the mast arms to prevent pests from entering.
- b. Align the mast arm to allow the signal heads to hang plumb at the correct height without using extensions.
- c. All Mast arms are to be galvanized unless indicated otherwise in the Plans.

NOTE: The Contractor shall submit a "Mast Arm Pole Chart" to the Engineer and the Office of Bridge and Structural Design for review and approval as described in Subsection 647.1.03.F of this Specification.

Verify pole hole orientations for pedestrian heads, pedestrian push button stations, luminaries arms, etc., with the Engineer prior to proceeding with traffic signal installation.

5. Aluminum Pedestrian Pedestals Poles

Install aluminum pedestal poles, which adhere to Section 850 on breakaway aluminum bases that meet the requirements for breakaway construction. See Section 925 for breakaway base requirements. See the Standard Detail Drawings for Pole and Foundation Details.

- a. Secure at least four anchor bolts in a concrete foundation as shown in the construction Detail.
- b. As an alternate to a concrete foundation install a Pedestal Foundation Anchor Assembly (Subsection 925.2.29). Install the foundation until the top of the base plate is level with the ground. Slide bolt heads through the keyhole and under the base plate against the bolt head keepers with threads up. Bolt the pole base to the foundation. Adhere to the manufacturer's instructions for installation.
 - 1) Use a Universal Driving Tool with the correct kelly bar adaptor and bolts supplied with the tool.
 - 2) Attach driving tool assembly to the foundation base plate using the bolts provided with each foundation. Be sure to align the tool so the holes in the tool line up with the proper bolt circle on the foundation.
 - 3) Stand the foundation, with the attached drive tool assembly, upright and attach the drive-tool-foundation to the kelly bar.
 - 4) Raise the kelly bar until the foundation swings free of the ground. Maneuver the kelly bar until the point of the foundation is over the marked installation location.
 - 5) Lower the kelly bar until the point of the foundation is forced into the ground and the helix is flush with the ground surface.
 - 6) Ensure the shaft of the foundation is plumb by checking the shaft with a level on two sides that are at least 90 degrees from each other. Recheck the shaft to be sure it is plumb when the foundation has penetrated 1 foot into the ground.
 - 7) When the base plate of the foundation is 1 (25 mm) to 2 (50 mm) inches above the ground line remove driving tool.
- c. Contain the wiring inside the pole or in approved hardware. Do not allow conduit outside the pole.
- d. Position the pedestal pole plumb and high enough to clear the pedestrian's head as shown in the Plans. Ensure that the bottom of the pedestrian signal housing including brackets is not less than 10 feet (3 m) from the ground line. If using a vehicle signal housing ensure pole is adequate to give signal head a height of 12 feet (3.6 m)
- e. Instruct the supplier to furnish a mill certificate that shows the alloy and physical properties of the steel used in fabricating the anchor bolts. The bolts may be subjected to a tensile and shear strength test.

6. Timber Poles

Timber poles do not require the use of concrete for filling the cavity around the pole base.

Use timber poles that meet the requirements of Section 861 and Section 639. Use Class II for all signal support poles. Use Class IV for aerial loop lead-in or communication cable if approved by the Engineer. Poles shall be inspected and include AWW stamp.

Drill wood poles to receive the eye bolt so that the angle of variance between the eye bolt and span wire at each connection is less than ten degrees (10°). See the Standard Detail Drawings for additional information.

Guy timber poles use single or double guy wires as shown in the Plans and as directed by the Engineer. Guy helper cables with separate guy wires when helper signal span cables are indicated in the Plans.

NOTE: Never attach down guy wires to eye bolts. Attach down guy wires to angle guy attachment only and install insulating rods on all down guy installations as detailed on Standard Detail Sheets.

AA. Pull Boxes

Ensure that pull boxes conform to the Standard Detail Drawings or Plan Detail Sheet. Install pull boxes as required by the Specifications and Plans.

1. Include provisions for drains in pull box excavations as specified.
2. Do not place the aggregate for the drain until the Engineer approves the excavation.
3. Do not set the pull box until the aggregate is in place.
4. Set the pull boxes in place, level, and install conduits as required. Conduit entrance shall be through the open bottom in Types 1, 2, 3, 4S and 5S. Conduit entrance shall be directly through cored holes in the side walls in Types 4 and 5. Conduit entrance shall be through the conduit terminators in Types 6 and 7.

Adjust the location of the pull box if necessary to avoid obstacles.

Where conduit entrance will be through the side wall in Types 4 and 5, or for conduit other than the terminator size provided in Types 6 and 7, use field cored conduit entrance holes in the side wall of the box. All field coring shall be made with a diamond-tipped masonry hole saw and according to the pull box manufacturer's recommendations.

Use an approved HDPE to EPVC coupling or an underground-type conduit adhesive where joining conduit or conduit bodies of dissimilar materials, such as HDPE-to-EPVC sweeps into pull boxes or installing into pull box conduit terminators.

- Do not locate pull boxes on the curb side of the signal pole in the intersection radius return
 - Install pull boxes so that the long dimension is parallel to the adjacent roadway
 - Install the pull box at a location that is level with the surrounding ground or pavement. Do not place a pull box in a ditch or depression. Unless otherwise shown in the Plans, when installed either in a sidewalk or in the ground, the top of the pull box shall be level with the sidewalk or ground surface.
5. Obtain the Engineer's approval, and begin backfilling and installing the frame and cover. Ground metal lids or covers.

BB. Span Wire and Span Wire Assemblies

Use span wire to support signal heads, cable, and other hardware only. Use messenger cable to support the aerial cable plant. Install span wire and messenger wire where specified in the Plans and in accordance with the Standard Detail Drawings. See Section 925 for information on span wire and messenger cable.

1. Install signal span wire not to exceed the sag specified by the pole manufacturer. Span wire used with timber pole installation shall have a minimum 2.5% sag. Span wire used with strain pole installation shall have a minimum 5% sag.
2. Use helper cables where specified in the Plans and on the Standard Detail Drawings.
3. For construction of a box or modified box span, use bullrings. Be consistent throughout the intersection in use of bull rings or strandvises. If bull rings are not used, strandvises shall be interlocked.

4. Install 12 inch (300 mm) diameter drip loop wrapped three times at the cable entrance to signal heads. Arrange cable so that it enters the structure from the bottom of the drip loop. Use a 24 inch (600 mm) diameter drip loop where cables enter a weatherhead and use 24 inch (600 mm) sag at corners of a span.
5. Use aluminum ties, lashing rods, or aluminum wrap to attach cables to span wire. When using aluminum wrap or aluminum ties spaced at 6 inch (150 mm) increments. Aluminum wrap shall have at least three turns of wrap. Do not use lashing wire on span wire.
6. Ground all span wire and down guy assemblies as shown on Standard Detail Sheets. Bond all span wire together and bond to ground at every pole.

CC. Traffic Signal Heads

Place traffic signal heads according to the signal design and Plan Detail Drawings. Deviation from the Plans must be according to the MUTCD, current edition and at the Engineer's approval. Ensure all Traffic Signal Heads at an installation have the same appearance for the signal heads and the LED Modules. The Ramp Metering enforcement device shall be mounted on the back of one signal per lane and wired to the red display. The enforcement device shall be able to be viewed from downstream on the ramp.

1. Install traffic signal heads at least 17 feet (5.1 m), but no greater than 19 feet (5.7 m) over the roadway. All vertically attached signal head assemblies shall have a metal support plate installed within the top section (RED) indication of the signal head for additional support and stability. Install Ramp Metering traffic signal heads as shown on the Plans Detail Drawings.
2. Adjust signal heads on the same approach to have the same vertical clearance.
 - a. Measure the clearance from the pavement to the lowest part of the assembly, including brackets and back plates.
 - b. Mount traffic signals on poles with a clearance of at least 12 feet (3.6 m) but no more than 19 feet (5.8m) above the sidewalk or pavement grade of the center of the highway, whichever grade is higher.
 - c. Mount and adjust Ramp Metering traffic signals as per the Plan Detail Drawings.
 - d. Mount and adjust Ramp Meter enforcement device (head) as per the Plan Detail Drawings.
3. Connect the signal cable to the wire in each signal head to provide the correct signal indication when the cables are connected to the controller cabinet back panels. Do not splice cables. Use wire nuts to make the connections to the LED signal modules leadin. Make all connections in the top section. Ensure that the black jacket is pulled into the signal head 6 inches (150 mm).
4. Install optically programmable (OP) signal heads as shown in the Plans and Standard Detail Sheet and as directed by the manufacturer.
5. Mount OP heads securely or tether them to limit movement.
6. Mask the OP lamp for directing visibility under the Engineer's supervision.
7. Tether signal heads that have tunnel visors longer than 12 inches (300 mm), at the discretion of the Engineer.
8. Attach signal heads to mast arms using rigid mounting brackets. See Section 925 for equipment information. Adjust signal heads on mast arms so that all red indications on the same mast arm are at the same elevation.
9. Install lane control heads for reversible lane systems and Ramp Metering heads as shown in the Plans and the Standard Detail Drawings. Center each signal over the lane or lanes under signal control.
10. Leave a vertical clearance for blank-out signs as shown on the Standard Detail Drawings. Use a spirit level to ensure that the bottom edge of each sign is horizontal.
11. All LED modules shall be labeled with their turn on date on the backside of the LED insert.

DD. Pedestrian Signal Heads

Install pedestrian signal heads on wood, concrete, steel strain poles, wood or steel auxiliary poles, or metal pedestal poles. Do not mix pole mount methods at the same intersection installation.

Install the pedestrian signal heads as shown on the Standard Detail Drawings and the intersection Plan Sheets and Drawings.

Leave a vertical clearance from the bottom of the head to the ground level of least 10 feet (3 m) unless specified by the Engineer.

1. Pedestal Mounts

Make pedestal mounts with a lower supporting assembly consisting of:

- a. A 4 inch (100 mm) slip-fitter bracket
- b. Hollow aluminum arms with a minimum inside cross-sectional area equal to a 1.5 inch (38 mm) pipe

Use serrated locking devices that firmly hold the signal heads in the required alignment.

- c. For Pedestal Mounts using side hinge “clamshell”. Secure “clamshell” to pedestal using 0.75 inch (19 mm) wide and 0.30 inch (0.75 mm) thick stainless steel bands.

2. Pole Mounts (Side of Pole)

For Metal poles, use side hinge “clamshell” mounting hardware or hardware as described in Wood Pole, Metal Pole alternate, or pedestrian pole.

a. Side Hinge “Clamshell”

- Secure the hubs to metal or concrete poles using 0.75 inch (10 mm) wide and 0.030 inch (0.75 mm) thick stainless steel bands. Secure the hubs to wood poles using lag bolts.

b. Wood Pole or Metal Pole alternate:

Make pole mounts with the upper and lower assembly consisting of:

- A post arm with a minimum cross-sectional area equal to a 1.5 inch (38 mm) pipe
- A post hub plate that matches the outside pole contour
- Secure the hubs to metal or concrete poles using 0.75 inch (19 mm) wide and 0.030 inch (0.75mm) thick stainless steel bands. Secure the hubs to wood poles using lag bolts, or banding.

Space the junctions so that each pedestrian signal head can be directed toward approaching traffic as needed.

Use serrated locking devices that hold the pedestrian signal heads in alignment.

EE. Blank-out Signs

Install blank-out signs as shown on Plans or as follows:

1. Securely fasten the signs to a stationary structure or to a messenger strand support system.
2. Center each sign over the lane or lanes under sign control, where applicable.
3. Leave a vertical clearance for blank-out signs as shown in the Plans or in Subsection 647.3.05.EE, “Traffic Signal Heads.” Use a spirit level to ensure that the bottom edge of each sign is horizontal.
4. Use terminal strips to connect each sign electrically to the external control box or cabinet.

FF. Battery Backup System (BBS)

Install Battery Backup System (BBS) if indicated on the Plans. Install in accordance with the option as indicated on the Plans and as directed by the Engineer.

With the Battery Backup submittal provide calculations for determining the size of the inverter and batteries based on the actual power requirements for the intersection installation. Ensure that all auxiliary items are included in the calculations. Ensure the submittal specifies the model number and the firmware revision that is being supplied.

Ensure that the external cabinet supplied meets the Section 925 Specifications and is base mounted next to the 332A cabinet as specified. Do not attach the battery external cabinet to the 332A cabinet unless otherwise specified. The external cabinet option allows for 2 separate configurations. Ensure that the correct configuration is installed in accordance with the Plans. Make all connections to the 332A cabinet through the base of the cabinets.

Provide date of manufacture of all batteries provided.

Ensure the BBS functions as required by the specifications. Ensure the “ON BATTERY” relay provides an input into the controller Alarm 2. Install the two hour run time circuitry from the normally open contacts in the BBS controller to the AC+ and the mercury coil terminal in the traffic signal cabinet.

Ensure that the BBS is enabled to communicate via Ethernet connection.

Provide copy of all documentation (Operation and Maintenance Manual) for items supplied. Include with documentation any communications firmware and cable required to interrogate the unit for status, setup or logs.

GG. Power Meters

Install Power Meters per GDOT Standard Drawings and Utility Provider’s Specifications.

647.3.06 Quality Acceptance

A. Testing Loop Detector Installation

Test each loop after installing the conductors in the slots cut in the pavement and before sealing.

- Perform a test where the loop wire is spliced to the shielded lead-in wire and where the shielded lead-in wire enters the controller cabinet
- If there are no splice points, such as in direct entry to the controller cabinet, only perform the tests at the controller
- Record the test results on the Loop Installation Data Sheet in Table 647-10, as shown in this section. Make copies of the data sheet as needed.
- Include the data sheets in the records, and place a copy in the controller cabinet.

Conduct the following five (5) tests to evaluate each loop installation for acceptance before sealing the loop in the pavement:

1. Induced AC Voltage Test

Read 0.05 V AC or less on a digital voltmeter or no deflection on the pointer of an analog meter.

2. Inductance

Inductance (I) is measured in microhenries (mH), and the total inductance is equal to the inductance of loop plus inductance of the loop lead-in.

Acceptable inductance is within 10 percent (10%) of the calculated value for a single loop with the design criteria listed in Table 647-8 and Table 647-9:

Table 647-8 Standard (Bi-Pole) Loops	
6 ft x 6 ft (3 turns) [1.8 m x 1.8 m (3 turns)]	I = 76 mH + 23 mH per 100 feet of loop lead-in cable I = 76 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 30 ft (2 turns) [1.8 m x 9 m (2 turns)]	I = 126 mH + 23 mH per 100 feet of loop lead-in cable I = 126 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 40 ft (2 turns) [1.8 m x 12 m (2 turns)]	I = 165 mH + 23 mH per 100 feet of loop lead-in cable I = 165 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 50 ft (2 turns) [1.8 m x 15 m (2 turns)]	I = 205 mH + 23 mH per 100 feet of loop lead-in cable I = 205 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 70 ft (2 turns) [1.8 m x 21 m (2 turns)]	I = 285 mH + 23 mH per 100 feet of loop lead-in cable I = 285 mH + 23 mH per 30 m of loop lead-in cable

Table 647-9 Quadrupole (QP) Loops	
6 ft x 30 ft (2, 4, 2 turns) [1.8 m x 9 m (2, 4, 2, turns)]	l = 269 mH + 23 mH per 100 feet of loop lead-in cable l = 269 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 40 ft (2, 4, 2 turns) [1.8 m x 12 m (2, 4, 2 turns)]	l = 349 mH + 23 mH per 100 feet of loop lead-in cable l = 349 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 50 ft (2, 4, 2 turns) [1.8 m x 15 m (2, 4, 2, turns)]	l = 429 mH + 23 mH per 100 feet of loop lead-in cable l = 429 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 60 ft (2, 4, 2 turns) [1.8 m x 18 m (2, 4, 2, turns)]	l = 509 mH + 23 mH per 100 feet of loop lead-in cable l = 509 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 70 ft (2, 4, 2 turns) [1.8 m x 21 m (2, 4, 2, turns)]	l = 589 mH + 23 mH per 100 feet of loop lead-in cable l = 589 mH + 23 mH per 30 m of loop lead-in cable

3. Leakage Resistance to Ground

The resistance to ground shall be 5 Mohm or more.

4. Loop Resistance

The resistance reading on an ohmmeter is approximately within ten percent (10%) of the calculated value:

- Acceptable Resistance @ (dc @ 68 °F [20 °C]):ohms(μ)
- No. 18 AWG wire: R = 29.4 μ /mile (or) R = 5.5 x 10⁻³ μ /ft. Approximately 5.5 ohms per 1,000 feet of No. 18 AWG wire)[R = 18.3 μ /km (or) R=18.3 x 10⁻³ μ /m]
- No. 14 AWG wire: R = 13.32 μ /mile (or) R = 2.523 x 10⁻³ μ /ft. Approximately 2.52 ohms per 1,000 feet of No. 14 AWG wire)[R = 8.3 μ /km (or) R=8.3 x 10⁻³ μ /m]
- No. 12 AWG wire: R = 5.2 μ /mile (or) R = 9.85 x 10⁻⁴ μ /ft. Approximately 0.98 ohms per 1,000 feet of No. 12 AWG wire [R = 3.24 μ /km (or) R = 3.24 x 10⁻³ μ /m]

5. Loop Q

Q at 50 kHz is greater than 5.

Report to the Engineer an out-of-range reading on any of the above tests. If a test is found unacceptable, remove the loop, install new wire, and repeat the test procedure.

Include in the test results:

- Type and model number of the equipment used (must be ohmmeter having a high resistance scale of R x 10 KW or greater)
- The last calibration date of the equipment and the scale used

Check the loop using an impedance tester to determine the natural operating frequency and impedance. Ensure that the completed units detect all motor vehicles. If the loop detection system does not meet the above test requirements, payment will not be made for work on the signal installation until corrections are completed.

Table 647-10 Loop Installation Data Sheet	
Conditions	
Project Number:	
Date:	
Contractor:	
Weather:	
Temperature:	
Pavement Condition - Wet () or Dry ()	
Location	
City or County:	Phase:
Intersection Name or Number:	Function:
Route Number(s) or Name (s):	Lane Location:
Installation or Plan Sheet Number:	No. of Turns:
Size and Type of Loop:	Downstream/Upstream: Down () Up ()
Distance from Stop Bar:	Distance E.O.P/Curb to Lead-in:
Distance Lead-in Cable:	
Material	
Loop Wire Color/Insulation Type/Gauge:	
Loop Lead-In Wire Color/Insulation Type/Gauge:	
Splice Point:	
Conduit Length from Curb/E.O.P. to Splice Point:	
Conduit Length from Splice Point to Cabinet:	
Sealant Type and Part Number:	
Sealant Manufacturer and Lot No.:	
Interconnect Wire Type and Length:	
Loop Tests	
1. Induced Voltage _____ 2. Inductance _____ microhenries 3. Leakage Resistance to Ground _____ megohms 4. Loop Resistance _____ ohms 5. Loop Q (Quality) _____ Q	
Comments	
Inspector's Name, and Title	

B. Field Tests

In addition to performing tests during installation and before turning on the equipment, perform the following tests on traffic signal circuits in the presence of the Engineer:

- Test each circuit for continuity

Test each circuit for grounds. If a test fails, repair the circuit immediately. New signals shall operate in the flash mode for three (3) days prior to beginning stop-and-go operation unless otherwise directed by the Traffic Engineer.

For Ramp Metering:

The Contractor shall submit to and obtain approval from the Engineer for Ramp Metering testing procedures for each specific Ramp Meter location. The testing procedure shall demonstrate that all components: hardware, cable, and connections furnished and installed by the Contractor operates correctly and that all functions are in conformance with the specifications.

At a minimum, the Contractor shall demonstrate to the Engineer:

- The IVDS and loop detectors at each location are functioning properly with expected accuracy as specified. IVDS burn-in period shall only be in conjunction with the Ramp Meter signal burn-in period of 30 days.
- The Ramp Meter signals function properly at all stages, including non-metering, startup, metering, and shutdown.
- In multi-lane configurations, the Ramp Meter can operate a simultaneous release of vehicles from all lanes and as well as an alternating or staggered release of vehicles from the two (or three) lanes.-
- Queue detectors are functioning as specified, including both queue detection and queue override.
- The Ramp Meter functions properly for both local traffic responsive and time of day operations.
- The advance warning sign can be clearly seen and can be activated and deactivated properly.
- The Ramp Meter can communicate properly with the hub/TMC.
- The traffic enforcement heads are operating as per the Plans and can be seen by enforcement personnel.

The Contractor shall coordinate closely with Engineer for conducting Ramp Meter field operational tests. Note: Pretest should be performed prior to calling the Engineer for formal field tests inspection. Pretest shall be defined as conducting all field tests in accordance with the Ramp Metering field testing procedures submitted and approved. Results of pretests shall be recorded and submitted to the Engineer. The Engineer may require the Contractor to address particular items noted in the pretest before beginning the actual field tests.

Operational test shall not begin until the field tests are accepted by the engineer-that will be performed during the Engineer's inspection. Begin operational tests after the Engineer is satisfied that all work has been completed. After the Ramp Meter has been placed in operation, the Contractor, in coordination with the system integrator, shall demonstrate that all equipment furnished and installed by the Contractor operates with all software and firmware as specified.

After successful completion of the test procedure, each Ramp Meter assembly shall go through a burn-in period for 30 consecutive days of normal Ramp Metering operations. During the burn-in period, the Contractor shall ensure that all Contractor-supplied equipment operates without failures of any type. If any equipment component malfunctions or fails to provide the specified functionality during the 30-day burn-in period, the Contractor shall replace or repair the defective equipment within 48 hours of notification by the Engineer.

After the malfunctioning component(s) have been repaired or replaced to the satisfaction of the Engineer, the Contractor shall begin a new 30-day burn-in period. The new 30-day burn-in period shall apply only to equipment components supplied by the Contractor. In the event of a failure or malfunctioning of equipment furnished by others which prevents the 30-day burn-in test from continuing, the Engineer will suspend the burn-in test and resume when the other equipment failures are corrected.

C. Operational Tests and Equipment Activation

After the equipment is installed and the field tests are completed successfully the Contractor shall request an initial equipment inspection. The Engineer shall notify in writing the District Signal Engineer a minimum of 14 working days prior to the inspection. The District Signal Engineer shall provide an in depth inspection and provide a written punch list of items for the Contractor to correct. Within fourteen days of the notification the Contractor shall correct the items noted.

Prior to activating new equipment and before removal of any existing intersection control or equipment, test and ensure any communications equipment is functional.

In the event that programming of the controller application is not a pay item for the contract the Engineer will notify the District Signal Engineer a minimum of 14 working days prior to activating the equipment.

Prior to activating equipment all Inductance loop, video detection equipment and detection zones shall be functional and operational.

When defects are resolved, the District Signal Engineer will begin the Contractor's operational test period to demonstrate that every part of the system functions as specified. The operational test shall be concurrent for the entire project.

1. The operational test for the traffic signal and Ramp Metering projects shall be at least thirty (30) days of continuous, satisfactory operation.
2. If a component or system fails or shows unsatisfactory performance, the condition must be corrected and the test repeated until thirty (30) days of continuous satisfactory operation is obtained.
3. The District Traffic Engineer will send the Engineer and Construction Office a letter showing the start, termination, suspension, or successful completion of the operational test period.
4. The District Engineer may recommend payment only after the successful completion of the test period.
5. The Contractor shall obtain written acceptance of the signal installation from the District Traffic Operations Engineer before Final Acceptance.

Costs incurred during operational tests, including power consumption, shall be at the Contractor's expense and included in the price bid for Contract Items.

647.3.07 Contractor Warranty and Maintenance

A. Traffic Signal Equipment Maintenance

See Section 150.

If a signal that is the responsibility of the contractor is not functioning properly:

1. Non-Emergency

Commence work on this signal within three (3) days of the written notice from the Engineer. Failure to respond shall result in a per calendar day charged against monies due or that may become due until the maintenance work is started. See Section 108.

The Contractor shall be responsible for all materials, equipment and expertise necessary to correct signal malfunction or repair.

The Department or local municipality will not be held responsible or liable for any alleged damage to the signal or as a result of the signal malfunction due to problems that may occur after the Department or local municipality forces make repairs.

Upon Notice to Proceed, The Contractor shall check and make any needed adjustments to time clocks on a monthly basis. No additional payment shall be made for this requirement.

2. Emergency

If the Engineer determines that the signal malfunction or failure is an operational hazard, the Contractor is to take corrective action within three (3) hours of the first attempt of notification. Response shall be considered only when qualified personnel and equipment are provided.

Failure to respond within three (3) hours will result in a non-refundable deduction of money of \$1,000.00 with an additional charge of \$500.00 per hour after the first three (3) hours until qualified personnel and equipment arrives on site and begins corrective action.

In addition, the cost of labor and material will be charged by the Department if the Department takes corrective action using its own forces or local municipality forces.

Total charges will not exceed \$5,000.00 (per emergency call) in addition to the material cost and labor incurred to make repairs by the Department or local municipality forces responding to the malfunction.

The Department will not be held responsible or liable for any alleged damage to the signal or as a result of the signal malfunction due to problems that may occur after Department or local municipality forces make emergency repairs.

The Contractor shall be responsible for all materials and equipment necessary to correct signal malfunction or repair. Final Acceptance will not be given until payment for such work is received.

B. Warranties

Provide manufacturer's warranties or guarantees on electrical, electronic, or mechanical equipment furnished, except state-supplied equipment.

Ensure that warranties and/or guarantees are consistent with those provided as customary trade and industry standard practices; or as otherwise specified in the Plans, Standard Specifications, or Special Provisions.

Upon Final Acceptance, transfer the manufacturer and Contractor warranties or guarantees to the Engineer. Ensure that warranties are continuous and state that they are subject to transfer.

Acceptance or approval of the Work does not waive warranties or guarantees where required by the Specifications. Final Acceptance will not be granted until all warranties and guarantees are received.

C. Guarantees

Repair and/or replace all equipment and material supplied under these Contract Documents which has been determined by the Engineer to not meet Specifications.

The Engineer reserves the sole right to determine suitability or unsuitability of the supplied equipment and material. The Contractor shall bear the total cost of delivery and transportation related to the repair and replacement of equipment and material throughout the duration of the Contract unless otherwise approved by the Engineer.

Transfer to the Engineer any warranties and guarantees remaining on all items after Final Acceptance. Perform transfer at 12:01 AM of the day following Final Acceptance.

647.4 Measurement

647.4.01 General

Traffic signal items complete, in place, and accepted of the kind, size, and type specified are measured as follows:

A. Traffic Signal Installation

Signal installation will be paid for by lump sum, including furnishing labor, materials, tools, equipment, and incidentals required to complete the work unless otherwise specified in this Subsection.

B. Communications Wire, Fiber Optic Cable

The number of feet (meters) of communications cable, wire or fiber optic cable is the actual number of linear feet (meters) of the size installed and accepted. Communications cable shall be paid for under Section 935.

B. Strain Poles, Traffic Signs

Highway signs are measured and paid for under Section 636. Strain poles are measured and paid for under Section 639.

C. Type 4, 4S, 5, 5S, 6 and 7 Pull Boxes

The number of pull boxes will be the actual number of pull boxes installed and accepted.

D. Loop Detector – Maintenance Milling and Resurfacing Projects

The number of loop detectors will be the actual number of loop detectors installed as specified in the Plans or as directed by the Engineer and accepted. Loop detector lead-in cable will not be measured separately for payment but will be included in the price submitted for Loop Detectors.

647.4.02 Limits

General Provisions 101 through 150.

647.5 Payment

647.5.01 General

The lump price bid for Traffic Signal and/or Ramp Meter Installation covers all Items of work in this Specification including furnishing labor, materials, tools, equipment, and incidentals required to complete the work.

Costs for installation, operation, maintenance, and removal of the traffic signal equipment are included under this Item.

Include payment for removal; disposal of existing pavement, shoulder surface, base and sub-grade; and restoration to original condition in the Contract Price for the items to which they pertain. They will not be paid for separately.

Furnishing, installing, and removing sheeting, bracing, and supports will not be paid for separately, but is included in the Contract Prices for other items.

No additional payment will be made for testing and storing State-supplied or Contractor-furnished traffic signal equipment.

No payment will be made for individual items unless a pay item is included in the Plans for the specific item.

Type 4, 4S, 5, 5S, 6, and 7 pull boxes will be paid for per each. Loop Detector will be paid for per each.

Payment will be made under:

Item No. 647	Traffic signal installation no-	Per lump sum
Item No. 647	Pull Box PB4	Per each
Item No. 647	Pull Box PB4S	Per each
Item No. 647	Pull Box PB5	Per each
Item No. 647	Pull Box PB5S	Per each
Item No. 647	Pull Box PB6	Per each
Item No. 647	Pull Box PB7	Per each
Item No. 647	Loop Detector	Per each

Payment for various elements of traffic signals will be as shown on the Plans.

A. Partial Payment

The Contractor may initiate a partial payment process for the lump sum traffic signal Items by submitting a written request to the Engineer. If the Engineer approves this request, payment will be made as follows:

Underground (loops, pull boxes, and conduits)	20%
Overhead (span, heads, poles, push buttons)	30%
Cabinet, contents, and base	20%
Successful completion of operational test	10%

B. Additional Items

Payment Items related to Section 647 are described in the following sections:

Strain Poles	Section 639
Highway Lighting	Section 680
Lighting Standards and Luminaries	Section 681
Electrical Wire, Cable, and Conduit*	Section 682
Grassing	Section 700
Timber Poles	Section 639 and Subsection 861.2.02
Sign Blanks	Section 912
Reflectorization Materials	Section 913
Traffic Signal Equipment/Ramp Metering Equip.	Section 925
* Payment for conduit installation shall be as described in Section 682 unless conduit installation is performed as part of a traffic signal installation, in which case measurement and payment is a part of the complete traffic signal installation. Payment is Lump Sum, unless listed as a separate pay item.	

647.5.02 Adjustments

General Provisions 101 through 150.

Section 648-Traffic Impact Attenuator

Delete Section 648 and substitute the following:

648.1 General Description

This work includes furnishing and installing impact attenuator units/arrays to conform with Plan locations and details and/or as directed by the Engineer. All impact attenuator units/arrays shall be tested and approved at the specified NCHRP 350 and/or MASH Test Level.

648.1.01 Definitions

General Provisions 101 through 150.

Gating-A gating end treatment allows a vehicle impacting the nose or the side of the unit at an angle near the nose to pass through the device

Non-Gating-A non-gating end treatment is capable of redirecting a vehicle impacting the nose or the side of the unit along the unit's entire length.

648.1.02 Related References

A. Standard Specifications

General Provisions 101 through 150

B. Referenced Documents

National Cooperative Highway Research Program (NCHRP) Report 350.

American Association of State Highway and Transportation Officials (AASHTO) Manual for Assessing Safety Hardware (MASH)

ASTM A 123/A 123M

QPL 64

AASHTO Roadside Design Guide (RDG)

648.1.03 Submittals

A. Installation Drawings

Submit all required certifications, test reports and drawings of details for completing the installation. Obtain Engineer's approval of these documents before beginning work on attenuator installation. Portable Impact Attenuator arrays shall meet the requirements of Ga. Std. 4960 and manufacturer specifications.

B. Manufacturer's Information

Submit certification from the manufacturer that the attenuator unit/array and its interconnecting hardware replicates an NCHRP-350 and/or MASH approved attenuator in an accepted letter from the FHWA. Furnish items such as manufacturer's brochures or specifications that completely outline the manufacturer's recommendations for materials and installation methods. All workmanship and materials are subject to the Engineer's approval.

648.2 Materials

A. Attenuator

1. Ensure that materials are in accordance with the manufacturer's recommendations, specifications and details.
2. Use attenuators that have been classified as "accepted" by the Department's Office of Materials and Research and approved by the Federal Highway Administration (FHWA) as meeting NCHRP-350 and/or MASH for the test level specified.
3. Where restoration and/or repair cannot be accomplished without the necessity of removing the unit/array from the original location, ensure replacement unit/array installation upon removal of the damaged unit/array. Furnishing, installing and maintaining the replacement will be at no additional cost.

4. Where required, ensure the approach end of the attenuator is equipped with a reflectorized object marker in accordance with Plan Details. The object marker may be furnished by the manufacturer of the attenuator or by others. Ensure that the front most section of the unit (the "nose") is yellow in color unless specified otherwise.
5. Where required, use an approved back-up system as specified in the Plans.
6. For non-gating attenuators, anchor the attenuator to the pavement according to a system recommended by the manufacturer for the type pavement encountered.
7. Use Class "A" concrete for concrete pads, concrete back up if used, and concrete transition where required.
8. Use metal components and hardware galvanized according to ASTM A 123/A 123M unless otherwise specified. Ensure all metal components and hardware of permanent attenuators are free of corrosion when shipped.
9. In freezing conditions, water and sand filled attenuators shall be freeze treated according to the manufacturer's recommendations.

648.2.01 Delivery, Storage, and Handling

A. General

General Provisions 101 through 150.

648.3 Construction Requirements

648.3.01 Personnel

General Provisions 101 through 150.

648.3.02 Equipment

General Provisions 101 through 150.

648.3.03 Preparation

General Provisions 101 through 150

648.3.04 Fabrication

A. Design Criteria and Type Selection

The Impact Attenuator Unit/array Type will be shown on the plans and designated by four characters.

- First character
Indicates the type of permanent installation.
The letter "P" designates a permanent (non-gating) installation that is considered reusable. Reusable installations have major components that may be able to survive multiple impacts intact and can be salvaged when the unit is being repaired. Some of the components, however, need to be replaced after a crash to make the entire unit crashworthy again.
The letter "S" designates a permanent (non-gating) installation that is considered low-maintenance and/or self-restoring. Low-Maintenance and/or self-restoring installations either suffer very little, if any, damage upon impact and are easily pulled back into their full operating condition, or they partially rebound after an impact and may only need an inspection to ensure that no parts have been damaged or misaligned.
- Second character
Designates the required NCHRP 350 and/or MASH test level.
- Third character
Indicates the traffic flow direction(s).
The letter "B" indicates bi-directional traffic typical for median applications or when the unit is installed on the shoulder of a two-lane, two-way traffic facility. Bi-directional means traffic flows in opposite directions at the site of the attenuator installation.
The letter "U" indicates uni-directional traffic flow typical for gore areas. Uni-directional means traffic on both sides traveling the same direction, from the nose to the rear of the unit.
The letter "S" indicates traffic flow in one direction on a single side only, typical for a unit located on the outside shoulder of a roadway with one-way traffic and the other side of the attenuator not being exposed to traffic.
- Fourth character
Indicates the numerical value of the width, in inches (millimeters), of the base of the rigid object that the attenuator will be shielding.

At bridge columns, this character is typically the width of the column plus the barrier base widths on the column sides at the pavement surface.

B. Example

A Type P-3-U-60 attenuator designates a permanent non-gating reusable installation tested and approved at NCHRP 350 and/or MASH test level 3

Uni-directional traffic flow a 60" (1500 mm) wide base for the rigid object being shielded.

Temporary portable units/arrays may be either gating or non-gating based on construction sequencing and/or field conditions, See Specification Section 150. Unless otherwise specified, all permanent attenuators shall be non-gating.

648.3.05 Construction

Field locate the position of the attenuator nose as shown on the plans prior to beginning the installation. Have any variations approved by the Engineer.

If the length of the attenuator unit/array is less than that indicated in the plan details for the specified conditions, the length of the concrete transition section or the length of the longitudinal barrier shall be increased as needed to provide a proper beginning point for the attenuator nose as shown in the plans.

The length of the system will be the combined length of the attenuator unit/array, the back-up system and any required transition. The length of the system shall not be excessive to the extent that it intrudes appreciably within the clear offset distance as shown on the plans.

The increased length of transition or barrier is considered as an incidental part of the system and will not be itemized separately.

Temporary portable units/arrays shall be installed, moved, reinstalled and maintained as required.

648.3.06 Quality Assurance

Obtain certification from the manufacturer that the impact attenuator unit/array installed meets all required approvals and specifications and furnish these to the Engineer.

Furnish any mill test/galvanizing test reports and heat numbers for all metal components of the unit per current requirements of the Department's Office of Materials and Research.

648.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

648.4 Measurement

Each traffic impact attenuator of the type specified, complete, in place and accepted at its location will be measured by the unit/array, including components, hardware, anchors, incidentals, freeze treated water or sand, and labor for each installation shown on the plans or as directed by the Engineer.

Site preparation work, as described under 648.3.03, "Preparation" is measured and paid for separately under the respective items involved unless otherwise specified.

Temporary units/arrays will be measured for payment only once, regardless of how often they are moved. See Specification Section 150.

648.4.01 Limits

General Provisions 101 through 150.

648.5 Payment

Impact Attenuator Units/Arrays will be paid for per each type specified. Payment is full compensation for all materials, labor, and incidentals necessary to complete the Item including installing, moving, reinstalling and maintaining Units/Arrays as required.

Payment will also include the back-up system and transitions where required.

Payment will be made under:

Item No. 648	Impact attenuator unit, Type P-	Per each
Item No. 648	Impact attenuator unit, Type S-	Per each

648.5.01 Adjustments

General Provisions 101 through 150.

Section 659—Hot Applied Preformed Plastic Pavement Markings

Delete Section 659 and substitute the following:

659.1 General Description

This work includes furnishing and placing hot applied preformed plastic pavement markings according to these Specifications and at locations shown in the Plans or as otherwise directed. Use applied markings that are very durable, impervious to oil and grease, and provide immediate and continuing retroreflectivity. Use hot applied preformed plastic pavement markings compatible with existing alkyd and hydrocarbon thermoplastic material.

659.1.01 Definitions

General Provisions 101 through 150.

659.1.02 Related References

A. Standard Specifications

General Provisions 101 through 150.

B. Referenced Documents

Federal Standard 595

Manual on Uniform Traffic Control Devices for Streets and Highways

AASHTO M 247

AASHTO M 249

ASTM E 274

ASTM E 303

ASTM D 476

QPL 74

659.1.03 Submittals

Transfer to the Department all manufacturer warranties or guarantees for heat-applied preformed plastic marking materials. Ensure warranties or guarantees can be transferred.

659.2 Materials

Select one of the following types of preformed marking material according to the Plans and Proposal.

Type HA – Hot Applied Preformed Thermoplastic Marking

Type HA-BLM – Hot Applied Preformed Thermoplastic Marking - Bike Lane Marking

Type HA-CBL - Hot Applied Preformed Thermoplastic Marking – Colorized Bike Lane

For a list of sources, see QPL-74.

A. Marking Characteristics

Ensure markings have the following characteristics:

1. Composition

Use pavement marking material consisting of a homogeneous mixture of high quality hydrocarbon resin, alkyd resin, or modified ester rosin solution in conjunction with aggregates, pigments, binders, and glass beads. Use thermoplastic material conforming to AASHTO M 249, except for relevant differences due to the material being supplied in a preformed state.

- a. Ensure Type HA-CBL pavement marking material contains no glass beads.

- b. Ensure Type HA and Type HA-BLM pavement marking materials contain at least 30% glass beads conforming to AASHTO M 247, Type 1. Use clear and transparent glass beads with a minimum index of refraction of 1.50 and at least 80% being true spheres.

2. Color

a. White

Use white markings containing at least 8% by weight of titanium dioxide pigment meeting ASTM D 476, Type II, Rutile. Ensure color meets Federal Highway White, Color 17886, as per Federal Standard 595. Use white markings with a minimum daylight reflectance (Y value) at 45°/0° of 80%.

b. Yellow

Use yellow markings containing sufficient yellow pigment to ensure the color meets Federal Highway Yellow, Color 13538, as per Federal Standard 595. Use yellow markings with a minimum daylight reflectance (Y value) at 45°/0° of 45%.

c. Colorized Bike Lane (Type HA-CBL)

Ensure colorized bike lane material meet the color requirements of the Manual on Uniform Traffic Control Devices.

3. Shapes and Sizes

Ensure prefabricated legends and symbols conform to the applicable shapes and sizes outlined in the “Manual on Uniform Traffic Control Devices for Streets and Highways.” As an option, turn arrows and combination arrows may come without pre-applied surface glass beads to allow reversibility.

4. Thickness

Ensure Type HA pavement marking material is at least 0.125 in (3.175 mm) thick.

Ensure Type HA-CBL and Type HA-BLM pavement marking materials are at least 0.090 in (2.286 mm) thick.

5. Retroreflectivity

Obtain pavement marking retroreflectivity values with a 30 meter geometry retroreflectometer.

Use preformed markings meeting the following initial minimum reflectivity values:

a. Non-Bike Lane Markings (Type HA)

	White	Yellow
Dry (ASTM E 1710)	350 mcd/lux/m ²	200 d/lux/m ²

b. Colorized Bike Lanes (Type HA-CBL)

Colorized bike lanes do not contain glass beads or reflective elements. Thus, colorized bike lanes are non-reflective.

c. Markings inside the Bike Lane (Type HA-BLM)

	White	Yellow
Dry (ASTM E 1710)	275 mcd/lux/m ²	--

6. Skid Resistance

Ensure the surface of Type HA preformed markings provides a minimum skid resistance of 45 BPN when tested according to ASTM E 303.

Ensure the surface of Type HA-BLM preformed markings provides a minimum skid resistance of 55 BPN when tested according to ASTM E 303.

Ensure the surface of Type HA-CBL preformed markings maintains a minimum level of friction of 32 when tested according to ASTM E 274 after one year in place.

B. Heating Characteristics

Use preformed markings capable of being affixed to bituminous or Portland cement concrete pavements by the use of the normal heat of a torch recommended by the manufacturer and according to the manufacturer’s installation guidelines.

Ensure preformed markings resealing characteristics allow it to fuse with itself and with previously applied marking material of the same composition under normal conditions of use.

659.2.01 Delivery, Storage, and Handling

Manufacture and package preformed markings permitting storage at normal shelf temperatures for up to one year after purchase.

659.3 Construction Requirements

659.3.01 Personnel

General Provisions 101 through 150.

659.3.02 Equipment

General Provisions 101 through 150.

659.3.03 Preparation

General Provisions 101 through 150.

659.3.04 Fabrication

General Provisions 101 through 150.

659.3.05 Construction

A. Pre-Conditions for Applying Markings with Heat

Apply markings under the following conditions:

1. Ambient temperature is 35 °F (2 °C) or above.
2. Pavement is clean, dry, and free of debris.
3. Prior to installation, follow manufacturer's recommendations for preheating road surface.

B. Applying Drop-On Glass Beads

1. Apply drop-on glass beads to the entire surface of preformed markings not having factory pre-applied surface beads.
2. Apply the drop-on glass beads to the preformed marking material while still in a liquid state. Use beads meeting the requirements specified in Subsection 659.2.A.
3. Do not apply drop-on glass beads to colorized bike lanes.

659.3.06 Quality Acceptance

Use material evaluated by the National Transportation Product Evaluation Program (NTPEP), the Georgia Department of Transportation or other State DOT test facilities.

Hot applied preformed plastic pavement markings meeting the laboratory test and field test requirements will be placed on the Georgia Department of Transportation Qualified Products List. Provide certification from the manufacturer certifying the Hot Applied Preformed Plastic Pavement Markings supplied to construction and maintenance projects is formulated of the same material as when tested by NTPEP and will conform to the requirements of this Specification. Products meeting all the requirements in this Section but fail to perform adequately in actual use will be removed from the Qualified Products List.

659.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

659.4 Measurement

Heat-applied preformed plastic pavement markings, complete in-place and accepted, are measured as follows:

A. Solid Traffic Stripe

Solid traffic stripe of the color, width, and type shown on the Plans or in the Proposal will be measured by the linear foot (meter) or linear mile (kilometer) as specified. Breaks or omissions in solid lines or stripes at street or road intersections will not be measured for payment.

B. Skip Traffic Stripe

Skip traffic stripe of the color, width, and type shown on the Plans or in the Proposal will be measured by the gross linear foot (meter) or gross linear mile (kilometer) as specified. The unpainted spaces between the stripes will be included in the overall measurement if the Plan ratio remains uninterrupted. Measurement will begin and end on a stripe.

C. Payment by Square Yard (Meter)

When hot applied preformed plastic pavement markings are paid for by the square yard (meter), the actual number of square yards (meters) covered will be measured in the overall measurement, including the space between the markings. The color, width, and type shall be indicated on the Plans.

D. Heat Applied Preformed Plastic

Each heat-applied preformed plastic word or symbol, complete according to Plan dimensions, is measured by the unit. The code for each word or symbol is stated in the Plan.

659.4.01 Limits

General Provisions 101 through 150.

659.5 Payment

Payment in each case will be full compensation for all aspects of heat-applied markings, including adhesives, cleaning, application, and traffic control necessary to complete the Item.

Payment will be made under:

Item No. 659	Hot applied preformed plastic solid pavement markings_____ in (mm), (color), (type)	Per linear foot (meter)
Item No. 659	Hot applied preformed plastic solid pavement markings_____ in (mm), (color), (type)	Per linear mile (kilometer)
Item No. 659	Hot applied preformed plastic skip pavement markings_____ in (mm), (color), (type)	Per gross linear foot (meter)
Item No. 659	Hot applied preformed plastic skip pavement markings_____ in (mm), (color), (type)	Per gross linear mile (kilometer)
Item No. 659	Hot applied preformed plastic pavement markings (color), (type)	Per square yard (meter)
Item No. 659	Hot applied preformed plastic pavement markings (color), (type)	Per linear foot (meter)
Item No. 659	Hot applied preformed plastic pavement markings (color), (type)	Per gross linear foot (meter)
Item No. 659	Hot applied preformed plastic pavement markings words or symbols (color), (type)	Per each

659.5.01 Adjustments

General Provisions 101 through 150.

Section 661—Standard and Wet Weather Epoxy Traffic Stripe

Delete Section 661 and substitute the following:

661.1 General Description

This work includes furnishing and applying reflectorized standard and wet weather epoxy traffic stripe according to the Plans and these Specifications.

This Item also includes applying words and symbols according to Plan details, Specifications, and the current Manual on Uniform Traffic Control Devices.

661.1.01 Definitions

Painted Stripes: Solid or broken (skip) lines. The location and color are designated on the Plans.

Skip Traffic Stripes: Painted segments between unpainted gaps on a designated sequence with a ratio of 1:3 [10 ft (3 m) segment and 30 ft (9 m) gap] as specified on the Plans. The location and color are designated on the Plans.

661.1.02 Related References

A. Standard Specifications

General Provisions 101 through 150.

Section 656—Removal of Pavement Markings

B. Referenced Documents

QPL 46

QPL 71

AASHTO M 247

ACI Method 503

ASTM			
D 476	D 711	D 6628	E 303
E 1710	E 2177	G 53-77	

Federal Standard No. 595A-17778

SOP 39

US EPA Method 3052

US EPA Method 6010

661.2 Materials

A. General Requirements

- Use epoxy material that has been evaluated (2 year field evaluation) by the National Transportation Product Evaluation Panel (NTPEP) test facility or other approved test facility.
- Use epoxy material produced from an approved source listed on QPL 46.
- Use an epoxy composition that is specifically formulated for use as a durable pavement marking material.
- Ensure the liquid markings consist of a two-component (Part A and Part B), 100% solids epoxy film formulated and designed to provide a simple volumetric mixing ratio as recommended by the manufacturer.
- Use white or yellow films for the markings, and use colors for bike lanes as required on the Plans. Ensure that these films are manufactured without the use of lead chromate pigments or other similar, lead-containing chemicals.
- Ensure that the mixed white epoxy contains not less than 13% by weight ASTM D 476 rutile titanium dioxide pigment to insure adequate opacity, hiding power, and reflective properties.

B. Glass Spheres and Reflective Composite Optics

Use glass spheres and/or reflective composite optics for the reflective media system that ensures the epoxy pavement markings meet the reflectance performance requirements in Subsection 661.3.04. Do not use beads and/or optics containing greater than 200 ppm total arsenic, 200 ppm total antimony, or 200 ppm total lead when tested according to the most recent US EPA Methods 3052 and 6010, or other approved methods.

Ensure glass spheres meet the requirements of AASHTO M 247. Use glass spheres produced from an approved source listed on QPL 71. Glass spheres conforming to an alternative gradation may be used provided all other requirements of AASHTO M 247 and this specification are met.

C. Finished Product Requirements:

1. Composition

Ensure that the retroreflective pavement markings consist of a mixture of high-quality resins, curing agent and pigments, with a reflective layer bonded to the top surface consisting of glass spheres and/or reflective composite optics.

2. Color

Meet these color requirements:

- White markings are pure white and free from dirt or tint.
- Yellow markings are “Federal Yellow” in color.
- Colors for bike lanes match the colors as shown on the Plans.
- The material does not change its color and brightness characteristics after prolonged exposure to sunlight.

3. Skid Resistance

Ensure the surface of the retroreflective marking provides an initial average skid resistance value of 45 BPN when tested according to ASTM E 303.

4. Color and Weathering Resistance

Ensure that the mixed epoxy compound, both white and yellow, when applied to 3 in (75 mm) x 6 in (150 mm) aluminum panels at 15 ± 1 mils ($0.381 \text{ mm} \pm 0.025 \text{ mm}$) thick without glass beads and exposed in a Q.U.V. Environmental Testing Chamber, as described in ASTM G 53-77, conforms to the following minimum requirements:

- The color of the white epoxy compound is not darker than Federal Standard No. 595A-17778, as measured by the Luminance factor Y according to ASTM D 6628.
- The color of the yellow epoxy compound meets the requirements of the “Federal Yellow” color chart.

5. Drying Time (Laboratory)

When tested in accordance with ASTM D 711 the epoxy marking material shall reach a no-pick-up condition in 30 minutes or less. Perform this test with AASHTO M247 Type 1 beads applied at a rate of 0.099 pounds per square foot (0.483 kg/m^2). Ensure that the drying time does not increase substantially with decreasing temperature.

6. Drying Time (Field)

When installed at 77 °F (25 °C), at a thickness of 25 ± 2 mils ($0.635 \text{ mm} \pm 0.051 \text{ mm}$) above the surface of the pavement on open graded asphalt concrete friction courses and 20 ± 2 mils ($0.508 \text{ mm} \pm 0.051 \text{ mm}$) on all other pavement types, and reflectorized with glass spheres and/or reflective composite optics, ensure that the epoxy markings reach a no-track condition in less than 30 minutes. Dry to “no-tracking” will be considered as the condition where no visual deposition of the epoxy marking to the pavement surface is observed when viewed from a distance of 50 feet (15 m), after a traveling vehicle’s tires have passed over the marking.

7. Adhesion to Concrete

Ensure that the epoxy pavement marking materials, when tested according to ACI Method 503, have such a high degree of adhesion to the specified concrete surface that there is a 100% concrete failure in the performance of this test. Condition the prepared specimens at room temperature 75 ± 2 °F (24 °C) for a minimum of 24 hours and maximum of 72 hours prior to the performance of this test.

8. Adhesion to Asphalt

Ensure that the epoxy pavement marking materials, when tested according to ACI Method 503, have such a high degree of adhesion to the specified asphalt surface that there is a 100% asphalt failure in the performance of this test. Condition the prepared specimens at room temperature 75 ± 2 °F (24 °C) for a minimum of 24 hours and maximum of 72 hours prior to the performance of this test.

661.3 Construction Requirements

661.3.01 Equipment

A. Traveling Traffic Striping Machine

To apply the traffic marking material, use a mobile, truck mounted and self contained pavement marking machine, specifically designed to apply two-component liquid materials, and glass beads, in a continuous and skip-line pattern.

Apply the two-component liquid materials through airless impingement mixing guns or static mix tubes. The guns must accommodate a plural component material system at the manufacturer's recommended volumetric mixing ratio. The guns must have the capacity to deliver materials from approximately 1.5 gal (5.7 L) to 3 gal (11.4 L) per minute to compensate for a typical range of application speeds of 3 mph (5 km/h) to 6 mph (10 km/h). Ensure that the machine travels at a uniform rate of speed both uphill and downhill.

Select the necessary accessories such as spray tip, mix chamber or static tube, and rod diameter to ensure proper mixing.

Ensure that the machine meets the following:

- The machine is capable of applying three separate stripes, either solid or skip, in any specified pattern by utilizing two adjacent spray nozzles at the same time.
- Each nozzle is equipped with satisfactory cutoff valves that will apply skip lines automatically.
- The application equipment is maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc.
- The truck-mounted unit is provided with accessories to allow for the marking of symbols and legends.

Ensure that the mobile applicator also includes the following features:

- The mobile applicator provides individual material reservoirs for the storage of Part A and Part B of the resin composition.
- The applicator is equipped with glass spheres dispensing equipment and capable of applying the glass spheres at a uniform rate.
- The application equipment is equipped with metering devices or pressure gauges on the proportioning pumps as well as stroke counters to monitor volumetric usage. Ensure that the metering devices or pressure gauges and stroke counters are visible.
- The applicator is equipped with all the necessary spray equipment, mixers, compressors, and other appurtenances to allow for the placement of reflectorized pavement markings in a simultaneous sequence of operations.

B. Hand Equipment

Use hand equipment for projects with small quantities of bike lanes, lane lines, edge lines, and center lines, or for conditions that require the equipment. Use hand equipment approved by the Engineer.

C. Cleaning Equipment

Use brushes, brooms, scrapers, grinders, high-pressure water jets, or air blasters to remove dirt, dust, grease, oil, and other foreign matter without damaging the underlying pavement.

661.3.02 Preparation

Notify the Engineer prior to the placement of the epoxy materials. Furnish the Engineer with the manufacturer's name and batch numbers of the epoxy materials and glass spheres to be used. Ensure that the approved batch numbers appear on the epoxy materials and glass spheres packages.

Before striping, thoroughly clean pavement surfaces of dust, dirt, grease, oil, and all other foreign matter.

Remove concrete curing compounds on new Portland cement concrete surfaces and existing pavement markings on both concrete and asphalt surfaces.

661.3.03 Construction

A. Atmospheric Conditions

1. Apply pavement markings only during conditions of dry weather and subsequently dry pavement surfaces. Ensure that the pavement surface temperature and the ambient temperature at the time of installation are both greater than 40 °F (4 °C) and that the relative humidity is not greater than 85%.
2. Moisture

Do not apply when the surface is moist. When directed by the Engineer, perform a moisture test on the Portland cement concrete pavement surface. Perform the test as follows:

- a. Place approximately 1 yd² (1m²) of roofing felt on the pavement surface.
- b. Pour approximately 1/2 gallon (2 L) of mixed epoxy onto the roofing felt.
- c. After 2 minutes, lift the roofing felt and inspect to see if moisture is present on the pavement surface or underside of the roofing felt.
- d. If moisture is present, do not proceed with the striping operation until the surface has dried sufficiently to be moisture free.

B. Alignment

Ensure that the traffic stripe is the specified length, width, and placement. On sections where no previously applied markings are present, ensure accurate stripe location by establishing control points at spaced intervals. The Engineer will approve control points.

C. Application

Apply the pavement markings as follows:

1. Apply the liquid marking material by spray method and according to the manufacturer's installation instructions.
2. Ensure marking configurations are in accordance with the "Manual on Uniform Traffic Control Devices."
3. Place the reflectorized pavement markings only on properly prepared surfaces and at the widths and patterns designated on the Plans. Do not begin marking operations until applicable surface preparation work is completed and approved by the Engineer.
4. Air-blast the surface first, to remove any dirt and residues from the pavement. Then apply the pavement markings as a continuous operation.
5. Ensure that mixing of the two components occurs in a static tube or impingement chamber prior to reaching the application spray nozzle.
6. Spray the mixed resin onto the pavement at a rate to obtain a minimum uniform dry thickness of 25 mils \pm 2 mils (0.635 mm \pm 0.051 mm) above the surface of the pavement on open graded asphalt concrete friction courses and 20 mils \pm 2 mils (0.508 mm \pm 0.051 mm) above the surface of the pavement on all other pavement types .
7. Glass Spheres and Reflective Composite Optics
 - a. Apply glass spheres and/or reflective composite optics to installed stripe surface above the minimum rate recommended by the epoxy material manufacturer to produce the required retroreflectivity value in accordance with Subsection 661.3.04.
 - b. Apply the glass sphere and/or reflective composite optics top-coating with a pressure-type gun specifically designed for applying glass spheres and/or reflective composite optics that will embed at least one-half of the sphere's and optic's diameter into the epoxy immediately after the material has been applied to the pavement.
 - c. Do not apply glass spheres or reflective composite optics to bike lanes.

Following an application of glass spheres and/or reflective composite optics, and upon curing, ensure that the resulting marking is an adherent reflectorized stripe of the specified thickness and width that is capable of resisting deformation by traffic.

D. Protective Measures

Protect newly applied striping as follows:

1. Traffic

Control and protect traffic with warning and directional signs during application. Set up warning signs before beginning each operation and place signs well ahead of the equipment. When necessary, use a pilot car to protect both the traffic and the striping operation.
2. Fresh Striping

Protect the freshly applied stripe using cones or other satisfactory devices. Repair stripe damage or pavement smudges caused by traffic according to Subsection 661.3.04.

E. Appearance and Tolerance of Variance

Continually deviating from stated dimensions is cause for stopping the work and removing the nonconforming stripe. (See Section 656.) Adhere to the following measurements:

1. Width
Do not lay stripe less than the specified width. Do not lay stripe more than 1/2 in (13 mm) over the specified width.
2. Length
Ensure that the 10 ft (3 m) skip stripe and the 30 ft (10 m) gap between skip segments vary no more than ± 1 ft (300 mm) each.
3. Alignment
 - a. Ensure that the stripe does not deviate from the intended alignment by more than 1 in (25 mm) on straight lines or curves of 1 degree or less.
 - b. Ensure that the stripe does not deviate by more than 2 in (50 mm) on curves exceeding 1 degree.

661.3.04 Quality Acceptance

A. General

For a minimum of 30 days from the time of placement, ensure the epoxy traffic pavement marking material shows no signs of failure due to blistering, excessive cracking, chipping, bleeding, staining, discoloration, oil content of the pavement materials, smearing or spreading under heat, deterioration due to contact with grease deposits, oil, diesel fuel, or gasoline drippings, spilling, poor adhesion to the pavement material, vehicular damage, and normal wear. In the event that failures mentioned above occur, ensure corrective work is completed at no additional cost to the Department.

Ensure that stripes and segments of stripes are clean-cut and uniform. Markings that do not appear uniform or satisfactory, either during the day or night, or do not meet Specifications or become marred or damaged by traffic or from other causes, will be corrected at the Contractor’s expense.

Obtain pavement marking retroreflectivity values with a 30 meter geometry retroreflectometer.

1. Correction of Alignment

When correcting a deviation that exceeds the permissible tolerance in alignment, do the following:

- a. Remove the affected portion of stripe, plus an additional 25 ft (8 m) in each direction in accordance with Section 656.
- b. Apply a new stripe according to these Specifications.

2. Removal of Excess Marking Material

Remove misted, dripped, or spattered markings to the Engineer’s satisfaction. Do not damage the underlying pavement during removal.

Refer to the applicable portions of Section 656.

B. Initial Retroreflectivity

1. Longitudinal Lines

Within 30 days of installation, ensure the in-place markings meet the following minimum reflectance values:

a. Standard Epoxy Traffic Material

	White	Yellow
Dry (ASTM E 1710)	400 mcd/lux/m ²	300 mcd/lux/m ²

b. Wet Weather Epoxy Traffic Material

	White	Yellow
Dry (ASTM E 1710)	400 mcd/lux/m ²	300 mcd/lux/m ²
Wet recovery (ASTM E 2177)	150 mcd/lux/m ²	125 mcd/lux/m ²

For each center line, edge line, and skip line, measure retroreflectivity 9 times for each mile; 3 times within the first 500 ft (152 m), 3 times in the middle, and 3 times within the last 500 ft (152 m). For projects less than one mile in length, measure retroreflectivity 9 times as above.

Record all retroreflectivity measurements on the form OMR CVP 66 in SOP 39.

2. Messages, Symbols, Transverse Lines, and Bike Lanes

Within 30 days of installation, ensure the in-place markings when tested according to ASTM E 1710 meet the following minimum reflectance value of 275 mcd/lux/m².

Perform at a minimum, one retroreflectivity measurement at one message, one symbol and one transverse line per intersection. Take one measurement per mile for locations other than intersections (i.e. school messages, railroad messages, etc.) Do not measure retroreflectivity of bike lanes.

C. Six Month Retroreflectivity (Longitudinal Lines)

Maintain the following minimum reflectance values for 180 days after installation:

1. Standard Epoxy Traffic Material

	White	Yellow
Dry (ASTM E 1710)	400 mcd/lux/m ²	300 mcd/lux/m ²

2. Wet Weather Epoxy Traffic Material

	White	Yellow
Dry (ASTM E 1710)	400 mcd/lux/m ²	300 mcd/lux/m ²
Wet recovery (ASTM E 2177)	150 mcd/lux/m ²	125 mcd/lux/m ²

Retest the in-place markings 180 days after installation to ensure these minimum retroreflectance values are maintained.

Note: The Contractor is responsible for retroreflectivity testing. Furnish initial test results to the Engineer within 30 days of application. Furnish 6 month test results to the Engineer within 180 days of application or prior to final acceptance, whichever comes first.

D. Thickness

Check the thicknesses on all skip lines, edge lines and center lines by placing durable tape, film, or metal plate of known and uniform thickness on an area to be striped. After the striper has passed over, remove the sample and measure the thickness with calipers or a micrometer.

For each center line, edge line, and skip line, measure thickness above the pavement 3 times for each mile; once within the first 500 ft (152 m), once in the middle, and once within the last 500 ft (152 m). For projects less than one mile in length, measure the thickness above the pavement 3 times.

Record thickness measurements on the form OMR CVP 66 in SOP 39.

Submit results to Engineer.

E. Corrective Work

For each mile section, if epoxy traffic stripe fails to meet Plan details or Specifications or deviates from stated dimensions, correct it at no additional cost to the Department. If removal of pavement markings is necessary, remove it according to Section 656 and replace it according to this Specification. No additional payment will be made for removal and replacement of unsatisfactory striping. Ensure corrective work is completed at no additional cost to the Department. Perform testing according to this Specification. Any retest due to failures will be performed at no additional cost to the Department. Furnish all test reports to the Department.

Retroreflectivity and Thickness Longitudinal Line Deficiency: A deficiency will ensue when two or more Location Average results as recorded on form OMR CVP 66 within a One-Mile Section do not meet the performance criteria herein. The entire line within this one mile section will be determined to be deficient. If the evaluated section is less than 1.0 mile, a single Location Average result not meeting the performance criteria herein will result in the entire line to be determined to be deficient.

Retroreflectivity Transverse Markings and Symbol Deficiency: A single Location Average result on the marking or symbol not meeting the performance criteria herein will result in the marking or symbol to be determined to be deficient.

661.3.05 Verification

See SOP 39.

661.4 Measurement

When traffic stripe is paid for by the square yard (meter), the number of square yards (meters) striped is measured and the space between stripes is included in the overall measurement.

Linear measurements are made on the striped surface by an electronic measuring device attached to a vehicle. On curves, chord measurements, not exceeding 100 linear feet (30 linear meters), are used.

Traffic stripe and markings, complete in place, are measured and accepted for payment as follows:

A. Solid Traffic Stripe

Solid traffic stripe is measured by the linear foot (meter), linear mile (kilometer), or square yard (meter). Breaks or omissions in solid lines or stripes at street or road intersections are not measured.

B. Skip Traffic Stripe

Skip traffic stripe is measured by the gross linear foot (meter) or gross linear mile (kilometer). Unstriped spaces between the skips are included in the overall measurements if the Plan ratio of 1 to 3 remains uninterrupted. Measurement begins and ends on a skip.

C. Pavement Markings

Pavement markings, words and symbols completed according to Plan dimensions are measured by the unit.

661.5 Payment

Payment will be full compensation for the work under this Section, including the following:

- Cleaning and preparing surfaces
- Furnishing materials, including epoxy, beads, and thinners
- Applying, curing, and protecting epoxy
- Protecting traffic, including providing and placing necessary warning signs
- Furnishing tools, machines, and other equipment necessary to complete the Item

Payment will be made under:

Item No. 661	Standard solid epoxy traffic stripe, _____ in (mm), (color)	Per linear mile (kilometer)
Item No. 661	Standard skip epoxy traffic stripe, _____ in (mm), (color)	Per gross linear mile (kilometer)
Item No. 661	Standard solid epoxy traffic stripe, _____ in (mm), (color)	Per linear foot (meter)
Item No. 661	Standard skip epoxy traffic stripe, _____ in (mm), (color)	Per gross linear foot (meter)
Item No. 661	Standard epoxy pavement markings, words, and symbols, (color)	Per each
Item No. 661	Standard epoxy traffic stripe, _____ in (mm), (color)	Per square yard (meter)
Item No. 661	Wet weather solid epoxy traffic stripe, _____ in (mm), (color)	Per linear mile (kilometer)
Item No. 661	Wet weather skip epoxy traffic stripe, _____ in (mm), (color)	Per gross linear mile (kilometer)
Item No. 661	Wet weather solid epoxy traffic stripe, _____ in (mm), (color)	Per linear foot (meter)
Item No. 661	Wet weather skip epoxy traffic stripe, _____ in (mm), (color)	Per gross linear foot (meter)
Item No. 661	Wet weather epoxy pavement markings, words, and symbols, (color)	Per each
Item No. 661	Wet weather epoxy traffic stripe, _____ in (mm), (color)	Per square yard (meter)

Section 663—Electric Transmission System

663 General Description

Specifications for this work will be included elsewhere in the Contract.

Section 800—Coarse Aggregate

Delete Section 800 and substitute the following:

800.1 General Description

This section includes requirements for coarse aggregate. All aggregate shall be the specified type, class, and grade, and shall meet the requirements for the intended use.

800.1.01 Related References

A. Standard Specifications

Section 424—Bituminous Surface Treatment

B. Referenced Documents

AASHTO	ASTM
T 11	C 295
T 27	E 30
T 96	G 23
T 104	
T 303	

GDT 104

GDT 129

GDT 133

QPL 2

SOP 1

800.2 Materials

800.2.01 Coarse Aggregate

A. Requirements

The Contractor shall use the type, group, class, and grade of coarse aggregate specified. For coarse aggregate sources, see QPL 2.

1. Coarse Aggregate Types

Type	Characteristics
Crushed stone	Sound, durable rock particles.
Gravel	Sound, durable rock without damaging coatings.
Air-cooled blast furnace slag	Sound, durable particles with uniform density and quality, or other slags that have a good service record. Dry slag shall weigh at least 70 lb/ft ³ (1120 kg/m ³) compacted and shall contain less than 30% glassy particles by weight. Do not use slag as aggregate for Portland cement concrete.
Synthetic aggregate	Sound, durable, expanded clay, shale, or other manufactured product.

2. Coarse Aggregate Groups

- a. Group I: Limestone, dolomite, marble, or any combination thereof. Ensure Group I aggregates meet the abrasion requirement for Class A stone when used in Portland cement concrete of any type or class.
- b. Group II: Slag, gravel, granitic and gneissic rocks, quartzite, synthetic aggregate, or any combination thereof.

3. Classes

Aggregates are classified by physical properties that determine how they are used.

- a. Do not blend aggregates that meet abrasion requirements with aggregates that do not meet requirements.
- b. “Class A“ and “Class B” aggregate used in Portland cement concrete, asphaltic concrete, and bituminous surface treatment shall meet these limits:

Percent Wear AASHTO T 96 (“B” Grading)		
	Class A	Class B
Group I Aggregates	0-40	41-55
Group II Aggregates	0-50	51-60

- c. “Class B” aggregates used in all applications other than Portland cement concrete, asphaltic concrete, or bituminous surface treatment shall meet these limits:

Percent Wear AASHTO T 96 (“B” Grading)	
	Class B
Group I Aggregates	41-55
Group II Aggregates	51-65

4. Soundness

Test coarse aggregate used in Portland cement concrete, bituminous surfaces, bituminous bases, aggregate bases, or surface treatment with five alternations of the magnesium sulfate soundness test.

- a. Use aggregate with a weight loss of less than 15 percent.
- b. The 15 percent soundness loss for a Class “CS” concrete is waived if it has a 5-year service record.
- c. If the material meets all the requirements except for the 15 percent soundness requirement, the material may be used in Zones 3 and 4 (see Subsection 424.3.05, “Construction Requirements”) under the following conditions:
 - 1) The aggregate in bituminous courses and in all types and classes of Portland cement concrete construction, except as stated in Group I, has a satisfactory five-year service record under similar service and exposure.
 - 2) The Engineer’s investigation shows that it equals or exceeds the quality of approved aggregate (in cases where the material’s uniformity changes at the source, or does not have a five-year service record).

5. Grades

Use coarse aggregate that is well graded within the limits and sizes specified in Table 800.1.

6. Detrimental Substances

- a. Detrimental substances include shale, weathered or decomposed rock, friable particles, or any substance that may be detrimental for the use intended.
- b. Do not use any aggregate that can cause a deleterious reaction.
- c. Do not use aggregates that contain Chrysotile (defined as fibrous serpentinite) as a temporary or permanent unbound surfacing for roads, nor as stabilizer for soil used as subgrade, base, or surface course.
- d. Detrimental substances shall not exceed the following limits:
 - 1) For Portland Cement Concrete:

Substance	Max % Allowed
------------------	----------------------

Mica schist—Materials defined in ASTM C 294 as phyllite or schist. Use GDT 104 to analyze these materials.	5
Materials that pass the No. 200 (75 µm) sieve.	1.5
Flat and elongated pieces (with lengths more than five times the average thickness).	10
Sulphur content computed as sulfide sulphur (for bridge-type structures)—If the sulphur content exceeds 0.01%, do not use the aggregate unless it passes a petrographic analysis and a weathering test equivalent to 6 months or more of exposure.	0.01
Other local detrimental substances. (Any Combination)	2.0
NOTE: Do not use aggregate in Portland Cement concrete that is capable of producing a deleterious reaction when combined with Portland Cement.	

2) For Asphaltic Concrete:

Substance	Max. % Allowed
Mica schist—Materials defined in ASTM C 294 as phyllite or schist. Use GDT 104 to analyze these materials. (Use this requirement for Interstate Construction, SMA mixes, OGFC mixes and all surface mixes on roadways ≥ 25,000 ADT).	10
Flat or elongated particles (with lengths more than five times the average thickness).	10
Glassy particles (slag).	30
Other local detrimental substances. (Any combination)	2.0

3) For Bituminous Surface Treatment:

Substance	Max. % Allowed
Mica schist—Materials defined in ASTM C 294 as phyllite or schist. Use GDT 104 to analyze these materials.	10
Material finer than No. 200 (75 µm) sieve.	
#5 Stone	0.5
#6 Stone	0.7
#7 Stone	0.7
#89 Stone	1.0
Flat and elongated particles (with lengths more than five times the average thickness).	10
Glassy particles (slag).	30
Other local detrimental substances. (Any combination)	2

7. Ensure that gravel used in Asphaltic Concrete and Bituminous Surface Treatment meets the following additional requirements:
- Consists of siliceous particles.
 - A minimum of 85%, by count, of the material retained on the No. 4 (4.75 mm) sieve has one or more fractured faces.
 - The fracture is for the approximate average diameter or thickness of the particle.
8. Ensure that No. 7 stone used in Bituminous Surface Treatment meets the following gradation:

¾" (19 mm)	½" (12.5 mm)	3/8" (9.5 mm)	No. 4 (4.75 mm)	No. 8 (2.36 mm)
100	85-100	40-70	0-15	0-5

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

Test	Method
Material that passes the No. 200 (75 µm) sieve	AASHTO T 11
Sulphur content	ASTM E 30, Leco method
Weathering	ASTM G 23
Petrographic analysis	ASTM C 295
Soundness (magnesium sulfate)	AASHTO T 104
Percent wear	AASHTO T 96
Aggregate gradation	AASHTO T 27
Reactivity	AASHTO T 303
Schist or phyllite	GDT 104
Flat and elongated particles	GDT 129
Friable Particles	GDT 133

D. Materials Warranty

General Provisions 101 through 150.

TABLE 800.1 - SIZES OF COARSE AGGREGATES

SIZE NO	NOMINAL SIZE SQUARE OPENINGS		AMOUNTS FINER THAN EACH LABORATORY SIEVE (SQUARE OPENINGS). %, BY WEIGHT										
	(1)	mm	2 1/2"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 8	No-16	No. 50
			63 mm	50 mm	37.5mm	25 mm	19 mm	12.5 mm	9.5 mm	4.75 mm	2.36mm	1.18 mm	300 μm
3	2-1	50 - 25	100	90-100	35-70	00-15	-----	00-5	----	-----	-----	-----	-----
357	2-No. 4	50 - 4.75	100	95-100	-----	35-70	-----	10-30	----	00-5	-----	-----	-----
4	1 1/2 - 3/4	37.5 - 19	-----	100	90-100	20-55	00-15	-----	00-5	-----	-----	-----	-----
467	1 1/2-No. 4	37.5 - 4.75	-----	100	95-100	-----	35-70	-----	10-30	00-5	-----	-----	-----
5	1-1/2	25 - 12.5	-----	-----	100	90-100	20-55	00-10	00-5	-----	-----	-----	-----
56	1-3/8	25 - 9.5	-----	-----	100	90-100	40-75	15-35	00-15	00-5	-----	-----	-----
57	1-No. 4	25 - 4.75	-----	-----	100	95-100	-----	25-60	-----	00-10	00-5	-----	-----
6	3/4-3/8	19 - 9.5	-----	-----	-----	100	90-100	20-55	00-15	00-5	-----	-----	-----
67	3/4-No. 4	19 - 4.75	-----	-----	-----	100	90-100	-----	20-55	00-10	00-5	-----	-----
68	3/4-No. 8	19 - 2.36	-----	-----	-----	100	90-100	-----	30-65	05-25	00-10	0-5	-----
7	1/2-No. 4	12.5 - 4.75	-----	-----	-----	-----	100	90-100	40-70	00-15	00-5	-----	-----
78	1/2-No. 8	12.5 - 2.36	-----	-----	-----	-----	100	90-100	40-75	05-25	00-10	0-5	-----
8	3/8-No. 8	9.5 - 2.36	-----	-----	-----	-----	-----	100	85-100	10-40	0-10	0-5	-----
89	3/8-No. 16	9.5 - 1.18	-----	-----	-----	-----	-----	100	90-100	20-55	0-15	0-10	0-5
9	No. 4-No. 16	4.75 - 1.18	-----	-----	-----	-----	-----	-----	100	85-100	10-40	0-10	0-5

(1) In inches, except where otherwise indicated. Numbered sieves are those of the United States Standard Sieve Series.

Section 801—Fine Aggregate

Delete Section 801 and substitute the following:

801.1 General Description

This section includes the requirements for fine aggregate. All aggregate shall be the specified type, class, and grade.

801.1.01 Related References

A. Standard Specifications

Section 800—Coarse Aggregate

Section 441—Miscellaneous Concrete

B. Referenced Documents

AASHTO	ASTM
T 11	C 295
T 21	
T 27	
T 112	
T 303	

GDT 4

GDT 5

GDT 63

GDT 75

GDT 132

QPL 1

SOP 1

801.2 Materials

801.2.01 Fine Aggregate for Cushion

A. Requirements

Use the type, class, and grade of fine aggregate specified.

1. Types

Use fine aggregate for cushion under granite curb or brick that is natural or manufactured sand with hard, strong, durable particles. Make manufactured sand from crushed gravel or stone meeting the requirements of Section 800. For a list of fine aggregate sources, see QPL 1.

2. Grades

Use fine aggregate for cushion with less than 10 percent total silt and clay. Grade as follows:

Size	Percent by Weight
Passing No. 4 (4.75 mm) sieve	100
Passing No. 16 (1.18 mm) sieve	25-75
Passing No. 100 (150 µm) sieve	0-25

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

- Sieve analysis—AASHTO T 27

D. Materials Warranty

General Provisions 101 through 150.

801.2.02 Fine Aggregate for Portland Cement Concrete of All Types and for Mortar

A. Requirements

1. Concrete and Mortar

Use fine aggregate for concrete and mortar that consists of natural sand, manufactured sand, or blends of natural and manufactured sands, having hard, clean, strong, durable, uncoated particles, meeting the requirements of the Specifications.

2. Manufactured Sand

Use manufactured sand made exclusively from crushed stone or gravel that meets **Section 800** requirements.

Manufactured sand used in concrete for construction of Portland cement concrete pavement, approach slabs, and bridge decks, shall be made from Group II aggregates as specified in **Subsection 800.2.01.A.2.**

3. Miscellaneous Concrete

Sand manufactured from synthetic aggregate meeting the requirements of **Section 800** may be blended with natural sands or manufactured sands made from crushed stone or gravel for use in miscellaneous concrete as described in **Section 441.**

Blend at least 50 percent natural sand or manufactured sand made from crushed stone or gravel.

4. Concrete Sand

Concrete sand that passes the No. 10 (2 mm) sieve shall have these characteristics:

Characteristic	Requirement
Durability index	70 or greater
Sand equivalent	70 or greater

5. Detrimental Substances

Keep detrimental substances within these limits:

Substance	Maximum Percent by Weight
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Clay lumps	0.5 maximum in total sample
Coal and lignite	0.5 maximum in total sample
All detrimental substances (any combination)	2.0 maximum in total sample
NOTE: Do not use fine aggregate in Portland cement concrete that is capable of producing a deleterious reaction with Portland cement	

- a. Provided the material passing the No. 16 (1.18 mm) sieve is petrographically determined to be essentially free of detrimental substances, test results for coal and lignite and other detrimental substances listed will be based upon a petrographic analysis of material retained on the No. 16 (1.18 mm) sieve.
- b. Calculations will be based upon the weighted average for the total sample.
- c. Other detrimental substances include constituents such as shale, weathered or decomposed rock, soft or friable particles, coated grains, or other substances that might be considered detrimental for the use intended.

6. Organic Impurities (natural sands only)

Ensure all fine aggregate is free from detrimental amounts of organic impurities.

Do not use materials that have colorimetric test (AASHTO T 21) results darker than the Reference Standard color plate.

7. Grades

Grade fine aggregates for Portland cement concrete and mortar as follows:

Size No.	Description	Total Percent by Weight Passing Each Sieve					
		3/ 8 in (9.5 mm)	No. 4 (4.75 mm)	No. 16 (1.18 mm)	No. 50 (300 µm)	No. 100 (150 µm)	No. 200 (75 µm)
10 NS	Natural concrete sand	100	95-100	45-95	5-30	0-10	0-3
20 NS	Natural mortar sand	100	100	90-100	15-50	0-15	0-5
10 SM	Standard manufactured concrete sand	100	95-100	45-95	8-30	1-10	0-4
10 FM	Fine manufactured concrete sand	100	95-100	45-95	15-42	6-22	0-9

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

Test	Method
Petrographic analysis	ASTM C 295
Material that passes a No. 200 (75 µm) sieve	AASHTO T 11
Organic impurities	AASHTO T 21
Sieve analysis	AASHTO T 27
Sand equivalent	GDT 63
Reactivity	AASHTO T 303

Test	Method
Durability index	GDT 75
Clay lumps	AASHTO T 112
Friable Particles	GDT 132
<p>NOTE: The percent passing the No. 200 sieve (75 µm) for size 10FM will be based upon the total percent determined by AASHTO T-11 and AASHTO T-27. The percent passing the No. 200 sieve (75 µm) for sizes 10NS, 20NS and 10SM will be as determined by AASHTO T-11 only.</p>	

D. Materials Warranty

General Provisions 101 through 150.

Section 805—Rip rap and Curbing Stone

Delete Section 805 and substitute the following:

805.1 General Description

This section includes the requirements for rip rap and curbing stone. Construction and material will be covered under the Special Provisions.

805.1.01 Related References

A. Standard Specifications

General Provisions 101 through 150.

B. Referenced Documents

AASHTO T 96

AASHTO T 104

ASTM C 295

ASTM D 5519

805.2 Materials

805.2.01 Rip rap

A. Requirements

1. Aggregate Quality

All rip rap stone shall be made of sound, durable rock pieces that meet these requirements:

Aggregate Quality	Maximum Percent
Abrasion loss "B" grading	65
Soundness loss	15
Flat and slabby pieces (length five times more than the average thickness)	5
Weathered and/or decomposed pieces and shale	5

2. Gradation for Stone-Dumped rip rap Type 1 and Type 3:

Severe Drainage Conditions or Moderate Wave Action (Type 1)*		
Size By Volume	Approx. Weight	Percent Smaller Than
4.2 ft ³ (0.12 m ³)	700 lbs (320 kg)	100%
1.8 ft ³ (0.05 m ³)	300 lbs (135 kg)	50% - 90%
0.8 ft ³ (0.02 m ³)	125 lbs (55 kg)	20% - 65%
*Between 0% and 15% of the Type 1 rip rap shall pass a 4 in (100 mm) square opening sieve.		

General Use Normal Drainage Conditions (Type 3)*		
Size By Volume	Approx. Weight	Percent Smaller Than
1.0 ft ³ (0.03 m ³)	165 lbs (75 kg)	100%
0.1 ft ³ (0.003 m ³)	15 lbs (7 kg)	10% - 65%
*Between 0% and 15% of the Type 3 rip rap shall pass a 2 in (50 mm) square		

opening sieve.

3. Stone for Plain Rip rap

The stones shall be clean and free of rock dust and fines.

- a. Process the stone so that the largest pieces have a volume of 2 ft³ (0.06 m³) or less.
- b. Ten percent or less of the total rip rap weight can consist of spalls that pass a 5 in (125 mm) sieve.

4. Stone Plain Rip rap for Stream Details

Stone Plain Rip rap for Stream Details shall be clean and essentially free of rock dust and fines. Stone shall be relatively flat on either side in the same dimension, preferably the long dimension. The material shall be processed such that 90 % of the particles within the size class shall have all dimensions within the ranges stated in the size classifications listed below:

TYPE A: Stone in this size class shall meet the following gradation requirements:

<u>SIZE</u>	<u>PERCENT BY WEIGHT</u>
Passing 12" Sieve	100
Passing 4" Sieve	0-25
Passing No.4 Sieve (4.75 mm)	0-10

Test: Method of Test shall be in accordance with the following:

Sieve Analysis	AASHTO: T 27
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For use as fill for upstream fill portions of Cross Vanes, Rock Vanes, J-Hook Vanes, and in other structures and areas as indicated on the Plans and Details, as directed and approved by the Engineer.

TYPE B: Generally 2-4 cubic feet and weighing 0.16-0.33 tons. Maximum weight for this size class can be 0.52 ton. The dimensions of these stones shall be 2' x 1' x 1' to 2' x 2' x 1'. Variability is allowed, however, with 1 foot being the smallest dimension and 2.5 foot being the largest dimension along any axis to be accepted within this size class. For use in Root Wad structures, Rock Vanes, Cross Vanes, J-Hook Vanes, and in other in-stream structures as indicated on the Plans and Details, as directed and approved by the Engineer.

TYPE C: Generally 4-8 cubic feet and weighing 0.33-0.66 tons. Maximum weight for this size class can be 1 ton. The dimensions of these stones shall be 2' x 2' x 1' to 2' x 2' x 2'. Variability is allowed, however, with 1 foot being the smallest dimension and 2.5 feet being the largest dimension along any axis to be accepted within this size class. For use in Root Wad structures, Rock Vanes, Cross Vanes, J-Hook Vanes, and in other in-stream structures as indicated on the Plans and Details, as directed and approved by the Engineer.

TYPE D: Generally 12-18 cubic feet and weighing 1.0-1.5 Tons. Weight range can vary between 1 ton up to 2 tons. The dimensions of these stones shall be 3' x 2' x 2' to 3' x 3' x 2'. Variability is allowed, however, with the smallest dimension being 2 feet and 3.5 feet being the largest dimension along any axis to be accepted within this size class. For use in in-stream structures such as Cross Vanes, J-Hook Vanes, Rock Vanes and in other structures and areas as indicated on the Plans and Details, as directed and approved by the Engineer.

TYPE E: Generally 24-72 cubic feet and weighing 2.0-6.0 tons. Weight range can vary between 2 tons up to and exceeding 6 tons with approval by the Engineer. The dimensions of this size class shall be to 6' x 4' x 3'. However, variability is allowed in that dimensions for this size class shall fall between the smaller 4' x 3' x 2' and a maximum as determined by the Engineer. For use in large in-stream structures such as Cross Vanes, J-Hook Vanes, Rock Vanes, Step Pools, and in other structures and in areas indicated on the Plans and Details, as directed and approved by the Engineer.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

Test	Method
Percent wear	AASHTO T 96
Petrographic analysis	ASTM C 295
Rip rap size	ASTM D5519-07
Soundness (magnesium sulfate)	AASHTO T 104

D. Materials Warranty

General Provisions 101 through 150.

805.2.02 Curbing Stone

A. Requirements

1. Type A:

Provide Type A curb that meets these requirements:

- a. Curb thickness and height as shown on the Plans
- b. Cut in lengths of not less than 5 ft (1.5 m) nor more than 10 ft (3 m)
- c. Tops dressed to an even, smooth surface for the full length
- d. Have straight, even edges
- e. Top sloped ¼ in (6 mm) from back to front
- f. Have squared ends to permit joints to be constructed not more than ½ in (13 mm) wide for the full depth of the curb.
- g. Backface hand dressed at least 4 in (100 mm) below that part of the back that will be exposed
- h. Front face hand dressed to a depth of 1 in (25 mm) below the indicated elevation of the base course, pavement or gutter
- i. Have ends of circular curb sections cut along radial lines to permit joints to be constructed not more than ½ in (13 mm) wide
- j. Circular curb conforms accurately to the required radius
- k. Dressed surfaces do not contain projections or depressions more than 3/8 in (10 mm) from the plane surface of the curb

2. Type B:

Provide Type B curb that meets these requirements:

- a. Dimensions shall be 5 in (125 mm) thick, 17 in (425 mm) deep, and 5 ft (1.5 m) long, unless otherwise specified.
- b. Front face to have a top margin draught with a smooth face 10 in (250 mm) deep
- c. Have a smooth face (Note: A quarry face may be considered a smooth face if free from holes and all bumps exceeding allowed tolerances are pointed level
- d. Tops of curbs present even, smooth faces for the full length
- e. Have squared joints that when abutted with adjacent sections, present no crack or joint exceeding ½ in (13 mm) in width

- f. Have ends of circular curb sections cut along radial lines to permit joints to be constructed not more than ½ in (13 mm) wide
- g. Circular curb conforms accurately to the required radius
- h. The allowable tolerances for Type B Curb dimensions are as follows:

Measurement Item	Dimension & Tolerance
Thickness	5 ¼ in (131 mm) +/- ¼ in (6mm)
Depth	17 in (425 mm) +/- 1 in (25 mm)
Top Surface	¼ in (6 mm) in 5 ft (1.5 m)
Side Surface	½ in (13 mm) in 5 ft (1.5 m)

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test for Percent Wear according to AASHTO T 96

D. Materials Warranty

General Provisions 101 through 150.

Section 812—Backfill Materials

Delete Section 812 and substitute the following:

812.1 General Description

This section includes the requirements for four types of material used as backfill: foundation backfill, Types I and II, imperfect trench backfill, Type III, and mechanically stabilized wall backfill.

812.1.01 Related References

A. Standard Specifications

Section 810—Roadway Materials

B. Referenced Documents

AASHTO T 11

AASHTO T 27

AASHTO T 96

AASHTO T 104

GDT 4

GDT 6

GDT 7

GDT 24a

GDT 24b

GDT 67

GDT 75

GDT 98

SOP 1

812.2 Materials

812.2.01 Foundation Backfill, Type I

A. Requirements

1. Use natural or artificial mixtures of materials consisting of hard, durable particles of sand or stone, mixed with silt, clay and/or humus material for Type I backfill.
2. Have the final blend of material meet the requirements of Class I or II soils in Subsection 810.2.01.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

Test	Method
Soil gradation	GDT 4
Volume change	GDT 6
Maximum density	GDT 7 or GDT 67

D. Materials Warranty

General Provisions 101 through 150.

812.2.02 Foundation Backfill, Type II

A. Requirements

1. Type

Use material meeting the requirements of Section 800, Class A or B aggregate, and SOP 1. Crushed concrete may be used provided it meets the requirements of Section 800 that are applicable to Group 2 Aggregates.

Do not use backfill aggregate containing soil or decomposed rock.

2. Gradation

Use material meeting the following gradation requirements:

Sieve Size	% Passing by Weight
1-1/2 in (37.5 mm)	100
1 in (25 mm)	80-100
No. 8 (2.36 mm)	0-5

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

Test	Method
Sieve analysis	AASHTO T 27

D. Materials Warranty

General Provisions 101 through 150.

812.2.03 Imperfect Trench Backfill, Type III

A. Requirements

1. Type

Use material made from either of the following for Type III backfill:

- A natural soil with a density of less than 95 lb/ft³ (1520 kg/m³) when tested with GDT 7
- An artificial mixture of soil and organic material, such as hay, leaves, or straw

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

The laboratory will:

1. Test the soil density with GDT 7.
2. Review the mixture and the percentages of each material, and approve a mixture suitable for the Project.

D. Materials Warranty

General Provisions 101 through 150.

812.2.04 Mechanically Stabilized Embankment Backfill

A. Requirements

Use material comprised of crushed stone, natural sand, or a blend of crushed stone and natural sand free of soils, organic or any other deleterious substances meeting the following additional requirements:

1. Crushed Stone

Use a material manufactured from Class A or B stone that is free of soil overburden, has a soundness loss of not more than 15 percent, and conforms to the requirements of SOP 1.

2. Natural Sand

May be used in conjunction with an approved, non-corrodible, extensible reinforcement. Use non-plastic material consisting of strong, hard, durable particles having a durability index of at least 70.

3. Gradation

Sieve Size	% Passing by Weight
4 in (100 mm)	100
2 in (50 mm)	80 -100
No. 10 (2 mm)	20 - 90*
No 200 (75 µm)	0 - 12
* Natural Sand may be 20 - 100	

4. Chemical

Ensure the material meets the following chemical requirements:

Test Method	Requirement
pH	*5.0 – 9.5
Resistivity	>3000 ohms/cm
Chlorides	<100 ppm
Sulfates	<200 ppm
Note: These chemical requirements are not applicable to MSE walls stabilized with an approved, non-corrodible, extensible reinforcement.	

*Sources of select backfill material having a pH between 4.5 and 5.0 may be used provided the interior face of the MSE wall panels have 3 inches of concrete cover over the reinforcement and the concrete used in the panels contains the following ingredients and proportions:

Material	% by Weight
----------	-------------

	Minimum	Maximum
Cement	30	--
Type F Fly Ash	10	20
Slag	50	60
Type F Fly Ash and Slag	--	70

5. Maximum Dry Density

Use backfill material with a maximum dry density equal to or greater than the design unit weight shown on the plans. If no maximum dry density of the backfill material is shown, use a weight of 125 lb/ft³ (2000 kg/m³).

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test the material as follows:

Test Method	Requirement
Percent Wear	AASHTO T96 ("A" Grading)
Sieve Analysis	AASHTO T 27
Material Passing No. 200 (75 μm) Sieve	AASHTO T 11
Durability Index	GDT 75
Maximum Dry Density	GDT 7 or GDT 24a, GDT 24b
Soundness (Magnesium Sulfate)	AASHTO T 104
pH	GDT 98
Resistivity	GDT 98
Chlorides	GDT 98
Sulfates	GDT 98

D. Materials Warranty

General Provisions 101 through 150.

Section 815—Graded Aggregate

Delete Section 815 and substitute the following:

815.1 General Description

This section includes the requirements for material to be used for base, subbase, or shoulder course material, and includes graded aggregate, unconsolidated limerock base, and recycled concrete base.

815.1.01 Related References

A. Standard Specifications

Section 800—Coarse Aggregate

B. Referenced Documents

AASHTO T 11

AASHTO T 27

AASHTO T 193

ASTM C 295

ASTM D 3042

FL DOT Method FM5-515

SOP-1

QPL-2

GDT 63

EPA Method 3050/6010

EPA Method 1311

EPA Polarized Light Microscopy Method

EPA Transmission Electron Microscopy Method

815.2 Materials

815.2.01 Graded Aggregate

A. Requirements

1. Type

Use graded aggregate base, subbase, or shoulder course material of uniform quality.

- a. Obtain the graded aggregate from an approved source or deposit that will yield a satisfactory mixture meeting all requirements of this Specification.
- b. Use material that is crushed or processed as a part of the mining operations, or, mix two grades of material so that when combined in the central mix plant, the mixture meets the specifications.
- c. May use material that is a blend of not more than 20 percent (max) recycled crushed concrete from known sources (see 815.2.03.A.1.a) and virgin aggregate if approved by the Office of Materials and Testing.

2. Retained on the No. 10 (2 mm) sieve

Ensure the material retained on the No. 10 (2 mm) sieve is Class A or B aggregate that meets the requirements of Section 800.

3. Passing the No. 10 (2 mm) sieve

Ensure material passing the No. 10 (2 mm) sieve is relatively free of detrimental substances, such as soil overburden, decomposed rock, and/or swelling silts.

4. Stabilized Mixtures

Ensure mixtures to be stabilized react satisfactorily when mixed with Portland cement. The Engineer will specify the percentage of Portland cement to use.

5. Gradation

Grade the graded aggregate base, subbase, or shoulder material as follows:

Sieve Size	Percent Passing By Weight
Group I Aggregates	
2 in (50 mm)	100
1-1/2 in (37.5 mm)	95-100
3/4 in (19.0 mm)	60-95
No. 10 (2 mm)	25-50 (Note 1, 2 and 3)
No. 60 (250 μm)	10-35
No. 200 (75 μm)	7-15
Group II Aggregates	
2 in (50 mm)	100
1-1/2 in (37.5 mm)	95-100
3/4 in (19 mm)	60-90
No. 10 (2 mm)	25-45 (Note 2 and 4)
No. 60 (250 μm)	5-30
No. 200 (75 μm)	4-11
NOTE 1: Group I aggregates having less than 37% passing the No. 10 (2 mm) sieve, shall have at least 9 percent passing the No. 200 (75 μm) sieve.	
NOTE 2: For graded aggregate stabilized with Portland Cement, 30-50 percent by weight shall pass the No. 10 (2 mm) sieve. All other requirements remain the same.	
NOTE 3: Material passing the No. 10 (2 mm) sieve shall have a sand equivalent of at least 20 for Group I aggregates.	
NOTE 4: Material passing the No. 10 (2 mm) sieve shall have a sand equivalent of at least 28 for Group II aggregates. Sand Equivalent values as low as 20 will be acceptable provided they are attributed exclusively to rock flour and the percent passing the No. 10 (2 mm) sieve does not exceed 40.	

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

Test	Method
Material that passes a No. 200 (75μm) sieve	AASHTO T 11
Gradation	AASHTO T 27
Sand Equivalent	GDT 63

D. Materials Warranty

General Provisions 101 through 150.

815.2.02 Unconsolidated Limerock Base

A. Requirements

1. Type

Use limerock base, subbase, or shoulder course material of uniform quality.

- a. To ensure uniform quality, the Department may restrict approved sources to specific mining areas, mining processes at a specific mining site, or both.
- b. Use a limerock base that yields a mixture to meet these Specifications.
- c. Use material that is crushed or processed as a part of the mining operations, or mix two grades of material so that when combined in the central mix plant the mixture meets the specifications.
- d. Use limerock base, subbase, or shoulder material that has the following characteristics:

Limerock bearing ratio	At least 100.
Deleterious substances	Do not allow chert or other extremely hard pieces that will not pass the 2 in (50 mm) sieve. Do not allow clay, sand, organics, or other materials in quantities that may damage bonding, finishing, or strength. All material passing the No. 40 (425 µm) sieve shall be non-plastic.
Carbonate content (magnesium or calcium)	At least 80%.

2. Gradation

Grade the limerock base so at least 97 percent by weight passes the 3-1/2 in (90 mm) sieve.

- a. Grade the material uniformly to dust. The fine portion passing the No. 10 (2 mm) sieve shall all be dust of fracture.
- b. Crush or break the limerock base, if necessary to meet size requirements before placing the material on the road.
- c. Ensure materials having soundness losses of 20% or less, comply with the following gradation requirements:

Gradation Requirements

Sieve Size	Percent Passing By Weight
2" (50 mm)	100
1-1/2" (37.5 mm)	95-100
3/4" (19 mm)	60-95
No. 10 (2.00 mm)	25-45
No. 60 (250 µm)	10-30
No. 200 (75 µm)	7-20

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

Test	Method
Material that passes a No. 200 (75µm) sieve	AASHTO T 11
Gradation	AASHTO T 27
Limerock bearing ratio	FL DOT Method FM5-515
Petrographic analysis	ASTM C 295
Total carbonates (insoluble residue)	ASTM D 3042

D. Materials Warranty

General Provisions 101 through 150.

815.2.03 Recycled Concrete Base

A. Requirements

1. Sources

Use recycled concrete materials from sources approved by the Office of Materials and Testing and listed on Qualified Products List 2. The criteria for approval will be as outlined in Standard Operating Procedure No. 1, “Monitoring the Quality of Coarse and Fine Aggregates” except the raw material will be recyclable concrete as specified herein rather than a geological deposit of aggregate.

2. Type

a. Recycled Concrete Base From Known Sources

Use recycled concrete derived exclusively from Portland cement concrete pavement or structural concrete as a base, subbase, or shoulder course.

Contaminants -

Ensure the recycled concrete is free of foreign material such as wood, steel reinforcement, clay balls, soils, epoxy expansion material, delivery unit washout material, miscellaneous paving materials, and non-construction materials.

b. Recycled Concrete Base From Unknown Sources

Use recycled concrete derived from sources of demolition materials that comply with the following requirements as a base, subbase or shoulder course. Due to the condition and type of raw material used to produce this base and the resulting difficulty in producing a consistent product, refer to SOP-1 for environmental requirements and preferred production procedures.

Ensure the finished product does not exceed the regulatory limit for asbestos of 1% (based on microscopy) and the regulatory limit for lead of 5 ppm. These determinations must be made prior to shipping.

Ensure the California Bearing Ratio (CBR) of the finished product is not less than 140.

Contaminants –

Ensure the recycled concrete is substantially free of foreign materials such as steel reinforcement, wood, clay balls, soils, epoxy expansion material and non-construction materials.

Note - Substantially free, in the context of this specification, shall mean concentrations of the above mentioned foreign materials individually shall not exceed 0.1 percent by weight, nor shall the total concentration of these materials exceed 0.5 percent by weight.

Keep the following ancillary materials within these limits:

Substance	Maximum Percent by Weight
Brick	3
Asphaltic Concrete	7
Weathered Rock	2
Any combination of Brick, Asphaltic Concrete or Weathered Rock	10

3. Gradation

Ensure the finished product meets the quality and gradation requirements of Subsection 815.2.01 for Group II aggregates, except the material finer than a #200 (75µm) sieve shall be 2 – 11%.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

Test	Method
Gradation	AASHTO T 27
Material that passes a #200 (75µm) sieve	AASHTO T 11
Sand Equivalent	<u>GDT 63</u>
California Bearing Ratio (CBR)	AASHTO T 193
Petrographic Analysis	ASTM C 295
Total Lead	EPA Method 3050/6010

Toxicity Characteristic Leaching Procedure	EPA Method 1311
Asbestos	EPA Polarized Light Microscopy Method <u>Or</u> EPA Transmission Electron Microscopy Method

D. Materials Warranty

General Provisions 101 through 150.

Section 822 — Emulsified Asphalt

Delete Section 822 and substitute the following:

822.1 General Description

This section includes the requirements for homogenous emulsions of asphalt, water, and emulsifying agents.

822.1.01 Related References

A. Standard Specifications

Section 820–Asphalt Cement

B. Referenced Documents

AASHTO T 50

AASHTO T 59

822.2 Materials

822.2.01 Emulsified Asphalt

A. Requirements

1. Type

Use materials not containing lumps and not showing separation during handling or storage of up to 30 days.

2. Grade

Use the various grades of emulsified asphalts meeting or exceeding the requirements in Table 1.

Table 1—Requirements for Emulsified Asphalt

Type	Rapid Setting		Slow Setting						Prime	
	RS-2h		SS-1h		SS-1		Non-Tracking Tack (Note 4)		EAP-1	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Tests on Emulsion: Viscosity Saybolt Furol at 77 °F (25 °C), (Sec.)			20	100	20	10 0	15	150	15	100
Viscosity Saybolt Furol at 122 °F (50 °C), (Sec.)	75	400								
(a) Settlement 5 Days, (%) Note:1		5		5		5		5		5
(b) Storage Stability Test 1 Day, (Percent)		1		1		1		1		1
(c) Demulsibility, 35 ml, 0.02N. CaCl ₂ , (%) Note: 2	60									
(d) Cement Mixing Test, (%) Note: 3				2.0		2.0				
Sieve Test, (%)		0.10		0.10		0.10		0.20		0.10
Oil Distillate by Volume (%)								1	5	12
Residue by Distillation	63		57		57		50		50	

(Percent AC)										
Tests on Residue from Distillation Test: Penetration 77 °F (25 °C) 100 gm/5 Sec. (dmm)	80	140	40	90	100	20 0		90		
Ductility at 77 °F (25 °C) 5 cm/min. (cm)	40		40		40					
Solubility in Trichloroethylene, (Percent)	97.5		97.5		97.5			97.5		
Float at 140 °F (60 °C), (Sec.)								20		
Softening Point, °F							125			

Notes: 1: The 24-hour (1 day) storage stability test may be used but does not predict that the 5 day settlement test will pass.

- 2: Ensure the demulsibility test is made within 30 days from date of shipment.
- 3: Ensure the cement mixing test will be applicable only if material is used in Asphalt Slurry Seal.
- 4: Failure to break within 30 minutes after application and/ or other than minor tracking of the tack once it has broken may subject the non-tracking tack product to re-evaluation for QPL-7 “Georgia’s List of Approved Bituminous Materials”.
- 5: Anionic emulsified asphalt is not compatible with cationic emulsions (CRS, CMS, CSS, CQS etc.). Ensure all equipment is thoroughly cleaned if cationic emulsion was previously present.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

Test	Method
Testing emulsified asphalts	AASHTO T 59
Float test	AASHTO T 50

D. Materials Warranty

General Provisions 101 through 150.

Section 824—Cationic Asphalt Emulsion

Delete Section 824 and substitute the following:

824.1 General Description

This section includes the requirements for cationic asphalt emulsions.

824.1.01 Related References

A. Standard Specifications

General Provisions 101 through 150.

B. Referenced Documents

AASHTO T 49

AASHTO T 44

AASHTO T 51

AASHTO T 53

AASHTO T 59

AASHTO T 72

AASHTO T 301

AASHTO T 302

ASTM D 5546 - 01

QPL 65

GDT 44

GDT 91

GDT 135

824.2 Materials

824.2.01 Cationic Asphalt Emulsion

A. Requirements

1. Use a homogenous emulsion. After thorough mixing at the viscosity testing temperature, the emulsion cannot show signs of separation within 30 days from manufacture date.
2. Use cationic emulsion grades that meet the requirements in Table 1, Table 2, Table 3 and Table 4.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

Test	Method
Testing emulsified asphalts (with the following exception): Frictional value	AASHTO T 59 GDT 44

D. Materials Warranty

General Provisions 101 through 150.

Table 1—Requirements for Cationic Emulsified Asphalt												
Type	Rapid Setting								Quick Setting			
Grade	CRS-1h		CRS-2h		CRS-3		CRS-2P (Note 1,7)		CQS-1h (Note 2 & 3)		CQS-1hP (Note 7)	
Uses	Tack Coat		Surface Treatment		Surface Treatment		Surface Treatment		Tack Coat Slurry Seal		Micro Surf.	
Tests	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Viscosity. Saybolt Furol at 77 °F(25 °C), sec. AASHTO T72									20	100	20	150
Viscosity. Saybolt Furol at 122 °F (50 °C), sec. AASHTO T72	20	100	100	400	100	500	100	400				
Storage stability test, (Note 5) 24 hours, % AASHTO T59		1		1		1		1		1		1
Settlement (Note 5) 5 days, % AASHTO T59				5		5		5		5		5
Demulsibility (Note 6) 35 ml, 0.8% dioctyl sodium sulfosuccinate, % AASHTO T59	40		40		40		40					
Coating Ability and Water Resistance: AASHTO T59												
Coating, dry aggregate												
Coating, after spraying												
Coating, wet aggregate												
Coating, after spraying												
Particle charge test AASHTO T59	Positive		Positive		Positive		Positive		Positive		Positive	
Sieve test, percent AASHTO T59		0.10		0.10		0.10		0.10		0.10		0.10
Oil distillate by vol. of emulsion, % AASHTO T59		3		3		3		3				
Residue, By Distillation, (%) (Note 7)	60		65		65		65		57		60	
Residue, By Evaporation, (%) (Note 8)	60		65		65		65		57		60	
Test on Residue from Distillation Test: Penetration, 77 °F (25 °C), 100 g, 5 sec., (dmm) AASHTO T49	40	100	80	140	60	110	80	175	40	90	40	90
Ductility, 77 °F (25 °C), 5 cm/min., (cm) AASHTO T51	40		40		40		125		40		40	
Solubility in trichloroethylene, % AASHTO T44	97.5		97.5		97.5		97.5		97.5		97.5	
Softening Point (°F) AASHTO T53 or other method approved by Office of Materials and Testing							125				135	
Elastic Recovery @ 77°F (25 °C), % AASHTO 301							50					

- Note 1: May be acceptable for limited use in conjunction with OMAT's recommendation
- Note 2: Slurry Seal containing CQS-1h must set sufficiently within 2 hours to allow traffic to resume.
- Note 3: In the laboratory, Slurry Seal containing CQS-1h shall not set while being mixed according to GDT 91 for a minimum of 90 seconds.
- Note 4: Failure to break within 30 minutes after application and/or other than minor tracking of the tack once it has broken may subject the non-tracking tack product to re-evaluation for QPL 7 "Georgia's List of Approved Bituminous Materials".
- Note 5: The 24-hour storage stability test may be used. However, this test does not predict whether the 5-day settlement test will pass.
- Note 6: Perform the demulsibility test within 30 days from date of manufacture.
- Note 7: AASHTO T 59 modified to include a maximum temperature of $350\text{ }^{\circ}\text{F} \pm 10\text{ }^{\circ}\text{F}$ to be held for 20 minutes.
- Note 8: Use Residue by Evaporation for all testing on residue material. Residue by Distillation may be used if penetration, softening point and/or ductility test fail on residue by evaporation.

Table 2—Requirements for Cationic Non-Tracking Tack		
Grade	Manufacturer Specific (Note 1)	
	Min.	Max.
Viscosity. Saybolt Furol at 77 °F(25 °C), sec. AASHTO T72	15	150
Viscosity. Saybolt Furol at 122 °F (50 °C), sec. AASHTO T72		
Storage stability test, (Note 2) 24 hours, % AASHTO T59		1
Settlement (Note 2) 5 days, % AASHTO T59		5
Particle charge test AASHTO T59	Positive	
Sieve test, percent AASHTO T59		0.20
Oil distillate by vol. of emulsion, % AASHTO T59		1
Residue, By Evaporation (%) (Note 3)	50	
Residue, By Distillation, (%) (Note 3)	50	
Test on Residue from Distillation Test: Penetration, 77 °F (25 °C), 100 g, 5 sec., (dmm) AASHTO T49		90
Softening Point (°F) AASHTO T53 or other method approved by Office of Materials and Testing	125	

Table 2—Requirements for Cationic Non-Tracking Tack (Notes)

Note 1: Failure to break within 30 minutes after application and/or other than minor tracking of the tack once it has broken may subject the non-tracking tack product to re-evaluation for QPL 7 “Georgia’s List of Approved Bituminous Materials”.

Note 2: The 24-hour storage stability test may be used. However, this test does not predict whether the 5-day settlement test will pass.

Note 3: Use Residue by Evaporation for all testing on residue material. Residue by Distillation may be used if penetration, softening point and/or ductility test fail on residue by evaporation.

Table 3—Requirements for Cationic Emulsified Asphalt										
Type	Medium Setting						Slow Setting			
Grade	CMS-2		CMS-1P (Note 1)		CMS-1P(R) (Notes 1 & 5)		CSS-1h		ECR-1	
Uses	Pre-Coating		Scrub Seal		Rejuv.Seal		Slurry Seal		(Note 2)	
Tests	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max.
Viscosity. Saybolt Furol at 77 °F(25 °C), sec. AASHTO T 72			50	350	20	100	20	100	50	500
Viscosity. Saybolt Furol at 122 °F (50 °C), sec. AASHTO T 72	50	450								
Storage stability test, (Note 3) 24 hours, percent AASHTO T 59		1		1		1		1		1
Settlement (Note 3) 5 days, percent AASHTO T59		5		5		5		5		5
Demulsibility (Note 4) 35 ml, 0.8% dioctyl sodium sulfosuccinate, percent										
Coating Ability and Water Resistance: AASHTO T 59										
Coating, dry aggregate	Good									

Coating, after spraying	Fair									
Coating, wet aggregate	Fair							Good		
Coating, after spraying	Fair									
Particle charge test AASHTO T59	Positive									
Sieve test, percent AASHTO T59		0.10		0.10		0.10		0.10		0.10
Oil distillate by volume of emulsion, percent AASHTO T59		12		0.5		0.5				6
Residue, By Evaporation, (%) (Note: 6) AASHTO T59	65		60		57		57		60	
Residue, By Distillation, (%) (Note: 6) AASHTO T59	65		60		57		57		60	
Test on Residue from Distillation Test: Penetration, 39.2 °F (4 °C), 200 g, 60 sec., (dmm) AASHTO T49			30	90	30	90				
Test on Residue from Distillation Test: Penetration, 77 °F (25 °C), 100 g, 5 sec., (dmm) AASHTO T49	100	250					40	90	125	225
Ductility, 77 °F (25 °C), 5 cm/min., (cm) AASHTO T51	40						40		40	
Solubility in trichloroethylene, % AASHTO T44	97.5						97.5		97.5	
Softening Point (°F) AASHTO T53 or other method approved by Office of Materials and Testing			125		125					

Table 3—Requirements for Cationic Emulsified Asphalt (Notes)

Note 1: May be acceptable for limited use in conjunction with OMAT’s recommendation

Note 2: Use ECR-1 in cold mix recycling of reclaimed pavements.

Note 3: The 24-hour storage stability test may be used. However, this test does not predict whether the 5-day settlement test will pass.

Note 4: Perform the demulsibility test within 30 days from date of manufacture.

Note 5: Use CMS-1P(R) as a Rejuvenation Seal diluted 1:1. Sample undiluted for testing at the manufacture site. Sample diluted for testing from distributor on project (Minimum Residue 29 %).

Note 6: Use Residue by Evaporation for all testing on residue material. Residue by Distillation may be used if penetration, softening point and/or ductility test fail on residue by evaporation.

824.2.02 Latex-Modified Cationic Asphalt Emulsion

A. Requirements

1. Latex Rubber Additive (LRA)
 - a. Ensure the LRA is a natural latex or an unvulcanized styrene-butadine rubber in an emulsified latex form.
 - b. Ensure that the LRA comes from an approved source listed in the Department’s current QPL 65 for use in cationic asphalt emulsion.
2. Latex-Modified Cationic Asphalt Emulsion
 - a. Use PG58-22 as the base asphalt.
 - b. Co-mill the LRA and asphalt cement while manufacturing the emulsified asphalt to produce a homogeneous mixture.
 - c. Ensure the latex-modified cationic asphalt emulsion, when undisturbed for 24 hours, shows no separation of emulsion and LRA and no color striations, but has a uniform color throughout.
 - d. Use a latex-modified cationic asphalt emulsion that meets the requirements in Table 4.

Table 4 – Requirements for Latex-Modified Cationic Asphalt Emulsion

Type	Rapid Setting	
Grade	CRS-2L	
Use	Surface Treatment	
Tests on Emulsion	Min	Max
Viscosity, Saybolt Furol @ 122 °F (50 °C), sec. AASHTO T 72	100	400
Storage stability, 24 hours, percent AASHTO T 59		1
Settlement, 5 days, percent AASHTO T 59		5
Demulsibility, 35 ml, 0.8% dioctyl sodium sulfosuccinate, percent AASHTO T 59	40	
Particle charge test AASHTO T59	Positive	
Sieve test, percent AASHTO T 59		0.10
Oil distillate by volume of emulsion, percent AASHTO T5 9		3
Residue by Evaporation, percent (Notes 1 & 2)	65	
Residue by Distillation, percent AASHTO T 59 (Note 3)	65	
Tests on Emulsion Residue	Min	Max
Penetration @ 77 °F (25 °C), 100g, 5 sec., (dmm) AASHTO T 49	80	175
Ductility, @ 77 °F (25 °C), 5 cm/min., (cm) AASHTO T 51	125	
Elastic recovery @ 77°F (25°C), (%) AASHTO 301	50	
Softening Point (°F) AASHTO T53 or other method approved by Office of Materials and Testing	125	
1. GDT-135, Residue by evaporation. 2. Use Residue by Evaporation for all testing on residue material. Residue by Distillation may be used if penetration, softening point and/or ductility tests fail on residue by evaporation. 3. AASHTO T 59 modified to include a maximum temperature of 350 °F ± 10 °F to be held for 20 minutes.		

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Test as follows:

Test	Method
Penetration of bituminous materials	AASHTO T 49
Ductility	AASHTO T 51
Softening point of bitumen	AASHTO T 53
Testing emulsified asphalts	AASHTO T 59
Viscosity	AASHTO T 72
Elastic recovery	AASHTO T 301
Polymer content of polymer-modified emulsions	AASHTO T 302
Solubility of asphalt binders in toluene by centrifuge	ASTM D 5546 – 01
Residue by evaporation of latex-modified asphalt emulsions	GDT-135

D. Materials Warranty

General Provisions 101 through 150.

Section 827— Pavement Patching Mastic

Delete Section 827 and substitute the following:

827.1 General Description

This section includes the requirements for a single component pavement patching mastic material composed of a polymer modified asphalt binder and aggregate. The patching mastic will be used for sealing, filling and repairing distresses in both Asphaltic Concrete and Portland Concrete pavements and bridge deck surfaces that required more extensive repair than typical crack and joint sealing. This patching mastic material is not intended for use on distresses requiring plant produced asphaltic concrete mixture patching.

827.1.01 Related References

A. Standard Specifications

Section 802 – Aggregates for Asphaltic Concrete

Section 820–Asphalt Cement

B. Referenced Documents

AASHTO T 30

ASTM D 36

ASTM D 5329 (Modified)

827.2 Materials

827.2.01 Requirements

Pavement Patching Mastic

A. Modified Asphalt Binder

The modified asphalt binder must meet the requirements established in Table 1.

B. Aggregate

The aggregate must be factory blended and meet the requirements established in Table 1.

C. Pavement Patching Mastic (Combined Materials)

The Pavement Patching Mastic must meet the requirements established in Table 1 and provide a well bonded, flexible, durable and traffic resistant repair when properly applied. Ensure packaging consist of cardboard boxes weighing approximately 40 pounds. Boxes must contain a quick melting release film covering that enables easy removal of product from the cardboard box. When purchased by the pallet, the units must be protected from the weather using a plastic pallet cover, with a minimum two layers of six month U.V. protected stretch wrap. Pallets must be labeled with product name, part number, lot number and net product weight.

Table 1—Requirements for Pavement Patching Mastic Components and Combined Material

Asphalt Binder Properties		
Test and/or Quality Characteristics	Test Method	Requirements
Cone Penetration, 77 °F (25°C) (dmm)	ASTM D 5329 - modified	60 maximum
Cone Penetration, 122 °F (50 °C) (dmm)	ASTM D 5329 - modified	120 maximum
Softening Point, (°F)	ASTM D 36	195 minimum
Aggregate Properties		

Aggregates		Must be factory blended to ensure a consistent and homogenous blend
Gradation (%)	AASHTO T 30	100 % passing 5/8" - Report
Abrasion Resistance (%)	ASTM C 131	25 % maximum - Report
Pavement Patching Mastic Combined Material		
Tensile Adhesion, PSI, (kPa)	ASTM D 5329 Modified (1)	25 PSI (172 kPa) with 0.5" (12.5 mm) minimum elongation
Flexibility	ASTM D 5329 Modified (2)	No cracking or loss of aggregate adhesion
Flow	ASTM D 5329 Modified (3)	3 mm maximum
Shelf Life		2 years minimum
Heating/Application Pot Life		8 hours minimum - 12 hours maximum

- Notes: 1. The specimen for the tensile adhesion is 75 mm length \times 50 mm width \times 37.5 mm thickness.
2. The specimen is 150 mm length \times 100 mm width \times 20 mm thickness. The test is performed at 77 °F (25 °C) and the specimen is bent over a 25.4 mm mandrel to 180 degrees over 10 seconds.
3. The specimen for the flow test is 60 mm length \times 40 mm width \times 13 mm thickness. Allow the specimen to cool for 1 hour at room temperature before removing from the mold. Allow the specimen to cool overnight prior seating on the base plate and starting the oven cycle. Seat the cooled specimen on the center of the base plate and mark a reference line around the specimen. Place the specimen in a 140 °F oven on a holding rack at a 75 ± 1 degree angle for 5 hours. Remove the specimen from the oven after 5 hours and measure any movement of the specimen below the reference line in millimeters.

D. Fabrication and Application

1. Ensure the pavement patching mastic component material is combined into a melter/applicator pot, heated, mixed and applied to the area requiring repair as recommended by the manufacturer. Ensure the material is heated no greater than 410 °F.
2. Ensure that the equipment produces and maintains a homogenous mixture of modified asphalt binder and aggregates at a uniform temperature without gradation related or temperature related segregation in the pavement patching mastic.
3. The material must provide a repair that can be opened to traffic once the pavement patching mastic has cooled and solidified.
4. General Provisions 101 through 150.

E. Acceptance

At the request of the Department, pavement patching mastic material may be subject to project related testing for acceptance when field application and and/or actual in-place performance indicates the material does not meet its intended purpose.

D. Materials Warranty

General Provisions 101 through 150.

E. Payment

Pavement Patching Mastic is paid for at the Contract Unit Price per pound. Payment is full compensation for furnishing materials including polymer-modified bituminous materials and aggregate.

Payment will be made under:

Item No. 827	Pavement Patching Mastic, including polymer-modified bituminous materials and aggregate	Per pound
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Section 828—Hot Mix Asphaltic Concrete Mixtures

Delete Section 828 and substitute the following:

828.1 General Description

This specification includes the requirements for hot mix asphaltic concrete mixtures, including:

- Open-graded surface mixtures (OGFC and PEM)
- Stone Matrix Asphalt mixtures (SMA)
- Superpave mixtures
- Fine-graded (4.75 mm) mixtures

828.1.01 Definitions

The Nominal Maximum Sieve Size is one standard sieve size larger than the first sieve to retain more than ten percent of the aggregate, per AASHTO R35. Mixture types in this section are identified according to Nominal Maximum Sieve Size.

828.1.02 Related References

A. Standard Specifications

Section 400-Hot Mix Asphaltic Concrete Construction

Section 800-Coarse Aggregate

Section 802-Aggregates for Asphaltic Concrete

Section 819-Fiber Stabilizing Additives

Section 820-Asphalt Cement

Section 831-Admixtures

Section 882-Lime

Section 883-Mineral Filler

B. Referenced Documents

AASHTO R30

AASHTO R35

AASHTO T 321

AASHTO T 112

AASHTO T 209

AASHTO T 305

AASHTO T 312

AASHTO T 245

AASHTO T 340

SOP-36

SOP-2

GDT 1

GDT 56

GDT 63

GDT 66

GDT 114

GDT 115

- GDT 123
- QPL 1
- QPL 2
- QPL 7
- QPL 26
- QPL 41
- QPL 77
- QPL 81

828.2 Materials

A. Requirements

Use approved hot mix asphalt concrete mixtures that meet the following requirements:

1. Produce each asphalt mixture according to a Department approved Job Mix Formula and Asphalt Mix Design, see Subsection 400.1 for submittal and approval of Job Mix Formulas.
2. Ensure individual acceptance test results meet the Mixture Control Tolerances specified in the appropriate table below, Subsections 828.2.01 through 828.2.04.
3. Ensure the Engineer approves all materials used to prepare and place the mixtures before incorporating them into the Work. Use only the ingredients listed in the approved Asphalt Mix Design and Job Mix Formula. For virgin aggregates use sources meeting the requirements of Section 802 and are listed in QPL 1 or QPL 2; for mixes in which local sand is permitted, use the approved sand source identified in the mix design. For mixtures containing Reclaimed Asphalt Pavement (RAP), use only RAP from the approved stockpile identified in the mix design. Use asphalt cement meeting the requirements of Section 820, from a source listed in QPL 7.
4. Obtain approved SMA mix designs, Superpave mix designs and 4.75 mm mix designs from a mix design laboratory certified by the Department. Obtain approved mix designs for types PEM and OGFC mixtures from the Department's Office of Materials, which produces and furnishes these mix designs.
5. Ensure all SMA mix designs are designed in accordance with GDT-123 ("Determining the Design Proportions of Stone Matrix Asphalt Mixtures"). Ensure SMA mix designs are verified and approved by the Department prior to use. Ensure Superpave and 4.75 mm mix designs are designed in accordance with SOP-2 ("Control of Superpave Bituminous Mixture Designs") and are approved by the Department as provided therein. Ensure these mixes are designed by a laboratory and technician certified in accordance with SOP-36, ("Certification of Laboratories and Personnel for Design of SMA and Superpave Asphalt Mixtures").
6. Use only mixtures composed of the aggregate groups and blends indicated in the Proposal and Plans by their pay item designations, defined as follows:

Pay Item Designation	Allowable Aggregate Groups
Group I or II	Group I, Group II, or Blend I
Group II only	Group II only
Blend I	Either 100% Group II material or a blend of Group I and Group II. Do not use Group I material for more than 60%, by weight, of the total aggregate nor more than 50%, by weight, of the coarse aggregate fraction.

7. For patching or leveling use Group I, Group II, or Blend I. Mix types for patching and leveling are specified in Subsection 400.3.03.B.
8. Include lime (hydrated lime) from an approved source and meeting the requirements of Section 882 in all paving courses except as otherwise provided in the Contract. For a list of approved sources of lime, see QPL 41.
 - a. Add lime to each mixture at the rate prescribed in the approved mix design.
 - b. Ensure mix designs using only virgin aggregate include lime at a minimum rate of 1.00 % of the total dry aggregate weight. Ensure mix designs using RAP include lime at a minimum rate equal to 1.00 % of the virgin aggregate fraction plus 0.50 % of the aggregate in the RAP fraction.
 - c. Add more lime or add lime plus an approved Heat-Stable Anti-Stripping Additive meeting the requirements of Section 831, if necessary to meet requirements for mixture properties, and pursuant to an approved mix

- design. However, the Department will not make additional payment for these materials. For a list of sources of Heat-Stable Anti-Stripping Additives, see QPL 26.
- d. Where specifically allowed in the contract on LARP, airport, and parking lot projects, an approved Heat-Stable Anti-Stripping Additive meeting the requirements of Section 831 may be substituted for hydrated lime. Ensure the mix gradation is adjusted to replace the lime with an equivalent volume of fines passing the 0.075 mm sieve. Add Heat-Stable Anti-stripping Additive at a minimum rate of 0.5 percent of the asphalt cement portion.
9. Use performance grade PG 64-22 or PG 67-22 asphalt cement in all mix designs and mixtures except as follows:
 - a. The State Materials Engineer will determine the performance grade to be used, based on Table 2 – Binders Selection Guideline for Reclaimed Asphalt Pavement (RAP) Mixtures, AASHTO M323 and laboratory testing results as required in Section 828.2.B for mixtures containing $\geq 25\%$ equivalent binder replacement for RAP/RAS mixtures.
 - b. Use only grade PG 76-22, excluding shoulder construction in the following mixes: all SMA, 12.5 mm PEM, 9.5 mm and 12.5 mm OGFC, 12.5 mm Superpave, on projects with ADT greater than 25,000; and in all mixtures for which polymer-modified asphalt is specified in the pay item.
 10. Use of local sand is restricted as follows:
 - a. Do not place mixtures containing local sand on the traveled way of the mainline or ramps of the Interstate System. Mixtures with local sand may be used for shoulder construction on these facilities.
 - b. Ensure local sand will not constitute more than 20 % of the total aggregate weight of any mix design or production mix.
 - c. Subject to the above limits, 19 mm, 12.5 mm, and 9.5 mm Superpave mix designs and 4.75 mm mix designs containing local sand may be used on projects with a current ADT not exceeding 2,000.
 - d. 25 mm Superpave mix designs containing not more than 20 % local sand may be used on all facilities except the main line and ramps of the Interstate System.
 - e. Obtain local sand for use in asphalt mixtures from a source approved by the Department.
 - f. Approval of local sand sources: The Department will sample, test, and approve sources of local sand. Ensure local sand contains no more than 7.0 % clay by weight and is free of foreign substances, roots, twigs, and other organic matter. Ensure sand is free of clay lumps, as determined by AASHTO T 112, and has a sand equivalent value exceeding 25%, as determined by GDT 63.

B. Fabrication

1. Design procedures: For all Superpave and 4.75 mm mixes, ensure conformance with the Superpave System for Volumetric Design (AASHTO T 312 and AASHTO R30), as adapted in SOP-2. Ensure Superpave mixes are designed at a design gyration number (N_{des}) of 65 gyrations and initial gyration number (N_{ini}) of 6 gyrations. Ensure 4.75 mm mixes, (N_{des}) are designed at 50 gyrations, and (N_{ini}) at 6 gyrations. Open-graded mix designs will be designed by the Department in accordance with GDT 114. In all cases, the procedure for measuring Maximum Specific Gravity (G_{mm}) is AASHTO T 209. In addition to gradation and volumetric analysis, ensure mix designs include the following performance tests, as applicable.
2. Performance Test:
 - a. Permeability test: Ensure Superpave and Stone Matrix mix designs include testing according to GDT -1 Measurement of Water Permeability of Compacted Asphalt Paving Mixtures. Ensure specimen air voids for this test are $6.0 \pm 1.0\%$. The average permeability of three specimens may not exceed 3.60 ft per day (125×10^{-5} cm per sec).
 - b. Moisture susceptibility test: Ensure mix designs of all types except open-graded surface mixes include testing for moisture susceptibility according to GDT 66. Ensure specimen air voids for this test are $7.0 \pm 1.0\%$ for all mixes excluding Stone Matrix mixes. Ensure specimen air voids for this test are $6.0 \pm 1.0\%$ for Stone Matrix mixes. The minimum tensile splitting ratio is 0.80, except a tensile splitting ratio of no less than 0.70 may be acceptable if all individual strength values exceed 100 psi (690 kPa). Ensure average splitting strength of the three conditioned and three controlled samples are not less than 60 psi (415 kPa) for either group. Ensure retention of coating as determined by GDT 56 is not less than 95%.
 - c. Rutting susceptibility test: Ensure mix designs of all types except Open-graded Surface Mixes (OGFC and PEM), and mixtures designed exclusively for trench widening include testing according to GDT 115 or AASHTO T 340. Design limits for this test are as follows: Ensure specimen air voids for this test are $5.0 \pm 1.0\%$ for all mix types incorporating ≥ 15 percent RAP, excluding SMA mixtures. Ensure specimen air voids for this test are $6.0 \pm 1.0\%$ for all mix types incorporating < 15 percent RAP, excluding SMA mixtures. Ensure specimen air voids for this test are $6.0 \pm 1\%$ for all SMA mixtures. Ensure testing temperature is 64°C (147°F) for all mix types except 19 mm and 25 mm Superpave mixes, which are to be tested at 49°C (120°F).

Ensure maximum deformation is 5.0 mm for all mixes except 4.75 mm mix, 9.5 mm Types I and II Superpave mixes. Ensure maximum deformation for the 9.5 mm Type II Superpave mix is 6.0 mm at 64°C (147°F) and 8.0 mm at 64°C (147°F) for the 4.75 mm and 9.5 mm Type I Superpave mix.

- d. Fatigue testing: The Department may verify dense-graded mix designs by fatigue testing according to AASHTO T 321 or other procedure approved by the Department.
- e. Hamburg Wheel-Tracking Test: The Department may verify Warm Mix Asphalt dense-graded mix designs or mix designs incorporating Polyphosphoric Acid (PPA) modified binders by Hamburg Wheel-tracking testing according to AASHTO T 324.

C. Acceptance

See Subsection 106.03 and Section 400. Ensure individual test results meet the Mixture Control Tolerances listed in Subsections 828.2, 828.2.01, 828.2.02, 828.2.03, or 828.2.04, whichever applies with the following exception. Ensure field verification results for rutting susceptibility tests performed on laboratory fabricated and/or roadway cores obtained from asphalt plant produced mixtures meet specified requirements with a tolerance of +2.0 mm.

D. Materials Warranty

See General Provisions 101 through 150.

828.2.01 Open-Graded Surface Mixtures

A. Requirements

Produce the mixture according to an approved mix design and Job Mix Formula. Ensure Open-Graded Surface Mixtures meet the following mixture control tolerances and mix design criteria:

Sieve Size	Mixture Control Tolerance, %	Design Gradation Limits, % Passing		
		9.5 mm OGFC	12.5 mm OGFC	12.5 mm PEM
3/4 in (19 mm) sieve	±0.0		100*	100*
1/2 in (12.5 mm) sieve	±6.1	100*	85-100	80-100
3/8 in (9.5 mm) sieve	±5.6	85-100	55-75	35-60
No. 4 (4.75 mm) sieve	±5.7	20-40	15-25	10-25
No. 8 (2.36 mm) sieve	±4.6	5-10	5-10	5-10
No. 200 (75 µm) sieve	±2.0	2-4	2-4	1-4
Range for % AC	±0.4	6.0-7.25	5.75-7.25	5.5-7.0
Class of stone (Section 800)		"A" only	"A" only	"A" only
Drain-down (AASHTO T305), %		<0.3	<0.3	<0.3

* Mixture control tolerance is not applicable to this sieve for this mix.

1. In 12.5 mm and 9.5 mm OGFC and 12.5 mm PEM mixes, use only PG 76-22 asphalt cement (specified in Section 820).
2. Ensure all OGFC and PEM mixes include a stabilizing fiber of the type (cellulose or mineral) specified in the mix design and meeting the requirements of Section 819. Ensure the dosage rate is as specified in the mix design and sufficient to prevent drain-down exceeding the above tolerance.

B. Fabrication

See Section 400.

828.2.02 Stone Matrix Asphalt Mixtures

A. Requirements

Produce the mixture according to an approved mix design and Job Mix Formula. Ensure Stone Matrix Asphalt mixtures meet the following mixture control tolerances and mix design criteria:

Sieve Size	Mixture Control Tolerance	Design Gradation Limits, Percent Passing		
		9.5 mm SMA	12.5 mm SMA	19 mm SMA
1- in (25 mm) sieve	±0.0			100*
3/4 in (19 mm) sieve	±7.0	100*	100*	90-100
1/2 in (12.5 mm) sieve	±6.1	98-100**	85-100	44-70
3/8 in (9.5 mm) sieve	±5.6	70-100	50-75	25-60
No. 4 (4.75 mm) sieve	±5.7	28-50	20-28	20-28
No. 8 (2.36) mm sieve	±4.6	15-30	16-24	15-22
No. 50 (300 µm) sieve	±3.8	10-17	10-20	10-20
No. 200 (75 µm) sieve	±2.0	8-13	8-12	8-12
Range for % AC (Note 1)	±0.4 (Note 2)	6.0-7.5	5.8-7.5	5.5-7.5
Design optimum air voids (%)		3.5 ±0.5	3.5 ±0.5	3.5 ±0.5
% aggregate voids filled with AC (VFA)		70-90	70-90	70-90
Tensile splitting ratio after freeze-thaw cycle GDT-66		80%	80%	80%
Drain-down (AASHTO T305), %		<0.3	<0.3	<0.3

*Mixture control tolerance is not applicable to this sieve for this mix.

**Mixture control tolerance is ± 2.0% for this sieve for 9.5 mm SMA mixes placed at spread rates greater than 135 lb/yd². For 9.5 mm SMA mixes placed at spread rates of 135 lb/yd² or less, 100 % passing is required on this sieve.

Note 1: Range for % AC is Original Optimum AC (OOAC) at 35 gyrations (Gyratory compactor) or 50 blows (Marshall compactor) prior to Corrected Optimum AC (COAC) calculation detailed in GDT 123 (Appendix A)

Note 2: Quality Acceptance Test Results for AC content that deviate > ± 0.3% from the approved Job Mix Formula (JMF) consistently over three lots may subject the mix to a revised AC content on project JMF at the discretion of the State Materials Engineer based on statistical trend.

1. Ensure SMA mixtures are compacted at 35 gyrations with the Superpave Gyratory compactor or 50 blows with the Marshall compactor.
2. Ensure SMA mixtures contain mineral filler and fiber stabilizing additives and meet the following requirements:
 - a. Asphalt cement grade PG-76-22 (specified in Section 820) is required in all SMA mixtures.
 - b. Aggregates for SMA meet the requirements of Subsection 802.2.02.A.3.
 - c. Use the approved mineral filler specified in the mix design and meeting the requirements of Section 883. Approved sources of mineral filler are listed in QPL 81.

Use the approved Fiber Stabilizing Additive of the type (cellulose or mineral) specified in the mix design and meeting the requirements of Section 819. Approved sources of Fiber Stabilizing Additive are listed in QPL 77. The dosage rate will be as specified in the mix design and sufficient to prevent drain-down exceeding the above tolerance.

B. Fabrication

See Section 400.

828.2.03 Superpave Asphalt Concrete Mixtures

A. Requirements for Superpave Mixtures (except Parking Lot Mixtures)

Produce the mixture according to an approved mix design and Job Mix Formula. Ensure Superpave Asphalt Concrete mixtures meet the following mixture control tolerances and mix design limits:

1. Gradation limits for Superpave mixtures are as follows:

Sieve Size	Mixture Control Tolerance	Design Gradation Limits, Percent Passing				
		9.5 mm Superpave Type I	9.5 mm Superpave Type II	12.5 mm Superpave (Note 1)	19 mm Superpave	25 mm Superpave
1½ in (37.5 mm)						100*
1- in (25.0 mm)	± 8.0			100*	100*	90-100
¾ in (19.0 mm)	±8.0**	100*	100*	98-100****	90-100	55-89**
½ in (12.5 mm)	±6.0***	98-100****	98-100****	90-100	60-89***	50-70
¾ in (9.5 mm)	±5.6	90-100	90-100	70-89	55-75	
No. 4 (4.75 mm) s	±5.6	65-85	55-75			
No. 8 (2.36 mm)	±4.6	48-55	42-47	38-46	32-36	30-36
No. 200 (75 µm)	±2.0	5.0-7.0	5.0-7.0	4.5-7.0	4.0-6.0	3.5-6.0
Range for % AC (Note 3)	± 0.4 (Note 2)	5.50-7.25	5.25-7.00	5.00-6.25	4.25-5.50	4.00-5.25

* Mixture control tolerance is not applicable to this sieve for this mix.

** Ensure mixture control tolerance is within ± 10.0% for this sieve for 25 mm Superpave.

***Ensure mixture control tolerance is within ± 8.0% for this sieve for 19 mm Superpave.

****Ensure mixture control tolerance is within ± 2.0% for this sieve for 12.5 mm and 9.5 mm mixes.

Note 1: Use PG 76-22 in 12.5 mm Superpave, excluding shoulder construction, on all projects with ADT greater than 25,000 as detailed in the Contract Pay Item.

Note 2: Quality Acceptance Test Results for AC content deviating > ± 0.3 % from the approved Job Mix Formula (JMF) consistently over three Lots may subject the mix to a revised AC content on the project JMF at the discretion of the State Materials Engineer based on statistical trend.

Note 3: Range for % AC is Original Optimum AC (OOAC) at 65 gyrations prior to the Corrected Optimum AC (COAC) calculation detailed in SOP 2 (Appendix D).

2. Volumetric limits are as follows:

Design Parameter	Mix Type	Limits
% of Max. Specific Gravity (Gmm) at design gyrations, (Ndes)	All	96%
% Gmm at the initial number of gyrations, Ni	All	91.5% maximum
% voids filled with asphalt (VFA) at Ndes	9.5 mm Type I	Min. 72; Max. 80
	9.5 Type II and 12.5 mm	Min. 72; Max. 76
	19 mm	Min. 71; Max 76

	25 mm	Min. 69; Max 76
Fines to effective asphalt binder ratio (F/Pbe)	9.5 mm Type I	0.6 to 1.4
	All other types	0.8 to 1.6
Minimum Film Thickness (microns)*	All	> 7.00
Minimum % Voids in Mineral Aggregate (VMA) Note: VMA shall be calculated using the effective specific gravity of the aggregate (Gse). See SOP-2SP.	25 mm	13.0
	19 mm	14.0
	12.5 mm	15.0
	9.5 Type I	16.0
	9.5 Type II	16.0

*Superpave Mixtures approved prior to January 31, 2012, may be adjusted to meet Minimum Film Thickness requirements by the State Materials Engineer.

B. Requirements for Superpave Parking Lot Mixes (NOT FOR STANDARD HIGHWAY/STREET PAVING)

1. Surface Layers for parking facilities:

Sieve Size	Mixture Control Tolerance	Design Gradation Limits, Percent Passing		
		4.75 mm Mix	9.5 mm Superpave Type I	9.5 mm Superpave Type II
1- in (25.0 mm) sieve	± 8.0			
3/4 in (19.0 mm) sieve	±8.0**		100*	100*
1/2 in (12.5 mm) sieve	±6.0	100*	98-100****	98-100****
3/8 in (9.5 mm) sieve	±5.6	90-100	90-100	90-100
No. 4 (4.75 mm) sieve	±5.6	75-95	65-85	55-75
No. 8 (2.36 mm) sieve	±4.6	60-65	48-55	42-47
No. 50 (300 µm) sieve	+3.8	20-50		
No. 200 (75 µm) sieve	±2.0	4-12	5.0-7.0	5.0-7.0
Range for Total AC	+ 0.4	6.00 - 7.50	5.50 - 7.25	5.25 - 7.00

* Mixture control tolerance is not applicable to this sieve for this mix.

****Ensure mixture control tolerance is within ± 2.0% for this sieve for 12.5 mm and 9.5 mm mixes.

2. Subsurface Layers for parking facilities:

Sieve Size	Mixture Control Tolerance	Design Gradation Limits, Percent Passing		
		12.5 mm Superpave	19 mm Superpave	25 mm Superpave
				100*

1- in (25.0 mm) sieve	± 8.0	100*	100*	90-100
3/4 in (19.0 mm) sieve	±8.0**	98-100****	90-100	55-89**
1/2 in (12.5 mm) sieve	±6.0***	90-100	60-89***	50-70
3/8 in (9.5 mm) sieve	±5.6	70-89	55-75	
No. 8 (2.36 mm) sieve	±4.6	38-46	32-36	30-36
No. 200 (75 µm) sieve	±2.0	4.5-7.0	4.0-6.0	3.5-6.0
Range for Total AC	+ 0.4	5.00 - 6.25	4.25 - 5.50	4.00 - 5.25

*Mixture control tolerance is not applicable to this sieve for this mix.

**Ensure mixture control tolerance is within ±10.0% for this sieve for 25 mm Superpave mixes.

*** Ensure mixture control tolerance is within ±8.0% for this sieve for 19 mm Superpave mixes.

****Ensure mixture control tolerance is within ±2.0% for this sieve for 12.5 mm and 9.5 mm Superpave mixes.

3. Volumetric limits for parking facilities are as follows:

Design Parameter	Mix Type	Limits
% of Max. Specific Gravity (Gmm) at design gyrations, Ndes)	All	96%
% Gmm at the initial number of gyrations, Ni	All	91.5 % maximum
% voids filled with asphalt (VFA) at Ndes	9.5 mm Type I	Min. 72; Max. 80
	9.5 Type II and 12.5 mm	Min. 72; Max. 78
	19 and 25 mm	Min. 71; Max 76
Fines to effective asphalt binder ration (F/Pbe)	9.5 mm Type I	0.6 to 1.4
	All other types	0.8 to 1.6
Minimum Film Thickness (microns)*	4.75 mm	> 6.00
	All other types	> 7.00
Minimum % Voids in Mineral Aggregate (VMA) Note: VMA shall be calculated using the effective specific gravity of the aggregate (Gse). See SOP-2	25 mm	13.0
	19 mm	14.0
	12.5 mm	15.0
	9.5 mm Types I, II	16.0

* Mixtures approved prior to January 31, 2012, may be adjusted to meet Minimum Film Thickness requirements by the State Materials Engineer.

C. Fabrication

See Section 400.

828.2.04 Fine-Graded Mixtures

A. Requirements

Produce the mixture according to an approved mix design and Job Mix Formula. Ensure that fine-graded mixtures meet the following mixture control tolerances and design limits:

ASPHALTIC CONCRETE - 4.75 mm Mix		
Sieve Size	Mixture Control Tolerance	Design Gradation Limits, % passing
1/2 in (12.5 mm) sieve*	±0.0	100*
3/8 in (9.5 mm) sieve	±5.6	90-100

No. 4 (4.75 mm) sieve	±5.7	75-95
No. 8 (2.36 mm) sieve	±4.6	60-65
No. 50 (300 μm) sieve	±3.8	20-50
No. 200 (75 μm) sieve	±2.0	4-12
Range for % AC	±0.4	6.00 – 7.50
Design optimum air voids (%)		4.0 – 7.0
% Aggregate voids filled with AC		60 - 80
Minimum Film Thickness (microns)**		> 6.00

* Mixture control tolerance is not applicable to this sieve for this mix.

** 4.75 mm Mixtures approved prior to January 31, 2012, may be adjusted to meet Minimum Film Thickness requirements by the State Materials Engineer.

B. Fabrication

See Section 400.

C. Acceptance

See Subsection 106.3 and Section 400. Ensure individual test results meet the Mixture Control Tolerances listed in Subsections 828.2, 828.2.01, 828.2.02, 828.2.03, 828.2.04, whichever applies.

D. Materials Warranty

See General Provisions 101 through 150.

Section 845—Thermoplastic Pipe

Delete Section 845 substitute the following:

845.1 General Description

This section includes the requirements for thermoplastic culvert pipe, underdrain pipe and slope drain pipe.

845.1.01 Related References

A. Standard Specifications

General Provisions 101 through 150.

B. Referenced Documents

AASHTO M 252

AASHTO M 294

AASHTO M 304

AASHTO M 330

ASTM F 477

ASTM F 949

ASTM D 3212

AASHTO Standard Specifications for Highway Bridges, Division II

QPL 51

845.2 Materials

845.2.01 Smooth-lined, Corrugated Polyethylene (PE) Culvert Pipe

A. Requirements

1. Use pipe meeting the requirements of AASHTO M 294, Type S.
2. Use pipe evaluated by the National Transportation Product Evaluation Program (NTPEP) test facility or other approved test facility.
3. Ensure pipe is produced from an approved source listed on QPL 51.
4. Use fittings and couplings as recommended by the manufacturer and approved by the Office of Materials and Research. The fittings and couplings shall comply with the joint performance criteria of AASHTO Standard Specifications for Highway Bridges, Division II. Ensure that the joints are “silt-tight” per the AASHTO bridge specifications.
5. Ensure joints have elastomeric seals that meet the requirements of ASTM F 477.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Have the manufacturer test the joint tightness according to ASTM D 3212 and certify the results according to Subsection 106.05.

D. Materials Warranty

General Provisions 101 through 150.

845.2.02 Polyvinyl Chloride (PVC) Profile Wall Drain Pipe

A. Requirements

1. Use pipe that meets the requirements of AASHTO M 304
2. Use pipe evaluated by the National Transportation Product Evaluation Program (NTPEP) test facility or other approved test facility.
3. Ensure pipe is produced from an approved source listed on QPL 51.
4. Use fittings and couplings as recommended by the manufacturer and approved by the Office of Materials and Research. The fittings and couplings shall comply with the joint performance criteria of AASHTO Standard Specifications for Highway Bridges, Division II. Ensure that the joints are “silt-tight” per the AASHTO bridge specifications.
5. Ensure joints have elastomeric seals that meet the requirements of ASTM F 477.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Have the manufacturer test the joint tightness according to ASTM D 3212 and certify the results according to Subsection 106.05.

D. Materials Warranty

General Provisions 101 through 150.

845.2.03 Polyvinyl Chloride (PVC) Corrugated Smooth Interior Drain Pipe

A. Requirements

1. Use pipe that meets the requirements of ASTM F 949.
2. Use pipe evaluated by the National Transportation Product Evaluation Program (NTPEP) test facility or other approved test facility.
3. Ensure pipe is produced from an approved source listed on QPL 51.
4. Use fittings and couplings as recommended by the manufacturer and approved by the Office of Materials and Research. The fittings and couplings shall comply with the joint performance criteria of AASHTO Standard Specifications for Highway Bridges, Division II. Ensure that the joints are “silt-tight” per the AASHTO bridge specifications.
5. Ensure joints have elastomeric seals that meet the requirements of ASTM F 477.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Have the manufacturer test the joint tightness according to ASTM D 3212 and certify the results according to Subsection 106.05.

D. Materials Warranty

General Provisions 101 through 150.

845.2.04 Corrugated Polyethylene Underdrain Pipe

A. Requirements

1. Use corrugated polyethylene underdrain and temporary slope drain pipe and fittings that meet the requirements of AASHTO M 252.
2. Ensure pipe is produced from an approved source listed on QPL 51.
3. Unless specified otherwise, pipe must be supplied in individual lengths not shorter than 10 ft. (3 m) Coils are not permitted for pipe 6 in (150 mm) or larger in diameter.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

1. Test any material prior to use that has been directly exposed to sunlight for more than 6 months.
2. Pipe lengths that have developed bends that cannot be sufficiently straightened will be rejected.
 - a. Straightening of individual pipe lengths by force will be permitted provided that no stress cracking occurs in the process.
 - b. Any pipe length that develops stress cracks will be rejected.

D. Materials Warranty

General Provisions 101 through 150.

845.2.05 Smooth-Lined Corrugated Polypropylene (PP) Pipe

A. Requirements

1. Use pipe meeting the requirements of AASHTO M 330, Type S.
2. Use pipe evaluated by the National Transportation Product Evaluation Program (NTPEP) test facility or other approved test facility.
3. Ensure pipe is produced from an approved source listed on [QPL 51](#).
4. Use fittings and couplings as recommended by the manufacturer and approved by the Office of Materials and Research. The fittings and couplings shall comply with the joint performance criteria of AASHTO Standard Specifications for Highway Bridges, Division II. Ensure that the joints are “silt-tight” per the AASHTO bridge specifications.
5. Ensure joints have elastomeric seals that meet the requirements of ASTM F 477.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Have the manufacturer test the joint tightness according to ASTM D 3212 and certify the results according to [Subsection 106.05](#).

D. Materials Warranty

General Provisions 101 through 150.

Section 912—Sign Blanks and Panels

Delete Section 912 and substitute the following:

912.1 General Description

This section includes the requirements for aluminum sign blanks and panels, and extruded aluminum sign panels.

912.1.01 Related References

A. Standard Specifications

General Provisions 101 through 150.

B. Referenced Documents

ASTM B 108

ASTM B 209 (B 209M)

ASTM B 221 (B 221M)

ASTM B 449

ASTM B 921

ASTM F 467 (F 467M)

ASTM F 468 (F 468M)

ASTM B 211 (B 211M)

912.2 Materials

912.2.01 Aluminum Sign Blanks

A. Requirements

1. Use aluminum sign blanks of the type, size, and shape specified:
 - a. Type I: Signs with an area of 9 ft² (0.84 m²) or less, at least 0.08 in, ± 0.005 in (2 mm, ± 0.125 mm) thick.
 - b. Type II: Signs with an area more than 9 ft² (0.84 m²), at least 0.10 in, ± 0.006 in (2.5 mm, ± 0.150 mm) thick.
2. Use metal for the sign blanks that meets the requirements of ASTM B 209 (B 209M), Alloy 6061-T-6 or 5052-H38.
3. See Table 1 for locations of bolt holes in the sign blanks. Punch or drill bolt holes 10 mm diameter. The table shows where the holes are located for each type and size of blank.
4. Submit to the Engineer at least 1 ft² (0.1 m²) of the sign material for each lot or shipment of each type.

Table 1—Bolt Hole Locations for Sign Blanks and Panels

1. Diamond-Shaped Blanks	
Size	Number of Holes Required and Spacing
24 in (600 mm)	2 holes, 12 in (300 mm) from center on diagonal line
30 in (750 mm)	2 holes, 15 in (375 mm) from center on diagonal line
36 in (900 mm)	2 holes, 18 in (450 mm) from center on diagonal line
48 in (1200 mm)	4 holes, 2 on each side 15 in (375 mm) from both vertical and horizontal center line

2. Square Shaped Blanks	
All sizes to 36 (900 mm)	2 holes, 3 in (75 mm) from edge in center of opposite sides
36 in (900 mm)	2 holes, 6 in (150 mm) from edge in center of opposite sides

NOTE: Drill or punch 24 in (600 mm), 30 in (750 mm), and 36 (900 mm) diamond and square blanks for use as either type.

3. Rectangular Sign Blanks	
Up to 48 in x up to 15 in (1200 mm x up to 375 mm)	4 holes, 1.5 in (38 mm) from the edge in the center of each side
Up to 48 in x 18 – 24 in (1200 mm x 450 - 600 mm)	4 holes, 3 in (75 mm) from the edge in the center of each side
36 (900) x 48 (1200 mm)	4 holes, 6 in (150 mm) from edge at 6 in (150 mm) from top and bottom edges
48 x 36 in (1200 x 900 mm) and 48 x 60 in (1200 x 1500 mm)	4 holes, 9 in (225 mm) from edge at 6 in (150 mm) from top and bottom edges
Over 48 x 12 in (1200 x 300 mm)	4 holes, 1/6 horizontal dimension from edge at 1.5 in (38 mm) from top and bottom edges
Over 48 x 24 in (1200 x 600 mm)	4 holes, 1/6 horizontal dimension from edge at 3 in (75 mm) from top and bottom edges
Over 48 x over 36 in (1200 x over 900 mm)	4 holes, 1/6 horizontal dimension from edge at 6 (150 mm) from top and bottom edges

4. Octagonal Sign Blanks	
30 x 30 in (750 x 750 mm) and 36 x 36 (900 x 900 mm)	2 holes, 3 in (75 mm) from edge on vertical center line
48 x 48 in (1200 x 1200 mm)	4 holes, 2 on each side, 15 in (375 mm) from both vertical and horizontal center lines

5. Triangular Sign Blanks (with point down)	
36 in (900 mm)	2 holes on vertical center line, spaced 3 in (75 mm) and 24 in (600 mm) from the top
48 in (1200 mm)	2 holes on vertical center line, spaced 4 in (100 mm) and 28 in (700 mm) from the top
60 in (1500 mm)	4 holes, 2 each 15 in (375 mm) from vertical center line, 3 in (75 mm) and 21 in (525 mm) from top

6. Circular Sign Blanks	
30 in (750 mm) Diameter	2 holes on vertical center line 12 in (300 mm) from center
36 in (900 mm) Diameter	2 holes on vertical center line 15 (375 mm) from center

7. Interstate Route Shield Blanks	
24 x 24 in (600 x 600 mm) and 30 x 24 in (750 x 600 mm)	2 holes on vertical center line spaced 3 in (75 mm) and 21 in (525 mm) from top

36 x 36 in (900 x 900 mm) and 45 x 36 in (1125 x 900 mm)	2 holes on vertical center line spaced 6 in (150 mm) and 30 (750 mm) from top
8. Isosceles Triangular Sign Blanks (with point to the right)	
30 x 40 x 40 in (750 x 1000 x 1000 mm)	2 holes, each 12 in (300 mm) from left edge, 7.5 in (188 mm) from horizontal center line
36 x 48 x 48 in (900 x 1200 x 1200 mm)	2 holes, each 15 in (375 mm) from left edge, 9 in (225 mm) from horizontal center line
9. Pentagonal Sign Blanks (with point up)	
30 in (750 mm)	2 holes on vertical centerline, spaced 3 in (75 mm) and 24 in (600 mm) from bottom edge
36 in (900 mm)	2 holes on vertical centerline, spaced 3 in (75 mm) and 27 (675 mm) from bottom edge

B. Fabrication

1. Complete all fabrication, including shearing, cutting, and drilling or punching holes, before treating the metal and applying the face material.
2. Cut the metal blanks to size and shape. Ensure that the blanks are free of buckles, warp, dents, cockles, burrs, and defects resulting from fabrication.
3. Finish each face of the blank to be a plain surface and flat.
4. Metal Treatment

Use conversion coating or anodizing to finish the metal before painting or applying the reflective sheeting.

- a. Ensure the finished sign blank or panel has a uniform, light-colored appearance, without splotches or stains.
- b. If the finishing procedure produces an iridescent color, ensure that the shade is uniform.
- c. Thoroughly clean the metal before finishing.
 - 1) Begin cleaning with an etch-type alkaline cleaner or with a vapor degreaser, using a trichloroethylene or perchloroethylene solvent.
 - 2) Use the cleaner according to the manufacturer's specifications.
 - 3) After using an alkaline etching cleaner, treat the metal with an acid solution or desmutting compound. Use the desmutting agent according to the manufacturer's specifications.
- d. Finish: Finish the metal with a conversion coating according to ASTM B 449, ASTM B921 or by anodizing with a chromic acid anodizing solution. Use the conversion coating compound according to the manufacturer's specifications.
- d. Handling: Carefully handle the metal with a device or with clean cotton gloves between all cleaning and finishing operations and before applying the finish material.

Be sure that the metal never comes in contact with greases, oils, dust, or other contaminants before you apply the finish material.

C. Acceptance

The Department will accept the sign blanks based on results of chemical and physical tests on the materials, approval of methods and procedures for metal treatment, and acceptable quality of work of the finished blank.

D. Materials Warranty

General Provisions 101 through 150.

912.2.02 Extruded Aluminum Sign Panels

A. Requirements

1. Use extruded aluminum sign panels close to the shape and size shown on the Plans.
2. Ensure that the aluminum meets the requirements of ASTM B 221 (B 221M), Alloy 6063-T6 or 6061-T6.
3. Accessories

Ensure that the accessories for fabricating the signs meet the following:

- a. Bolts: Use bolts for connecting the panels that are 3/8 in (M10x1.5), tolerance grade 16 UNC 2A thread (6G threads), and 3/4 in (19 mm) long. Use bolts that meet the requirements of ASTM F 468 (F 468M), Alloy 2024-T4.
 - b. Hex Nuts: Use hex nuts with tolerance grade 4 threads that meet the requirements of ASTM F 467 (F 467M), Alloy 6061-T6.
 - c. Washers: Use washers that meet the requirements of ASTM B 209 (B 209M), Alloy 2024-T4.
 - d. Posts Clips: Use clips as shown on the Plans and that meet the requirements of ASTM B 108, Alloy 356-T6.
 - e. Post Clip Bolts: Use bolts that are 3/8 in (M10x1.5), tolerance grade 16 UNC 2A thread (6G threads), and 1-3/4 in (44 mm) long, and meet the requirements of ASTM F 468 (F 468M), Alloy 2024-T4.
 - f. Post Clip Nuts: Use hex locknuts that meet the requirements of ASTM B 211(B 211M), Alloy 2017-T4.
 - g. Post Clip Washers: Use washers that meet the requirements of ASTM B 209 (B 209M), Alloy 2024-T4.
4. Tolerances

Ensure that the sections are within the established commercial tolerances of the aluminum industry.

- a. Ensure that all panels 6 in (150 mm) wide have a nominal weight of 1.115 lb/ft (1.7 kg/m). Use these sections only at the top of signs that do not conform to 1 ft (300 mm) modules.
 - b. Ensure that all panels 1 ft (300 mm) wide have a nominal weight of 2.707 lb/ft (4.0 kg/m). Use these sections as the normal sign panel.
 - c. Before supplying an alternate extruded panel section of equal or greater section moduli with dimensions suitable to use hardware, as shown on the Plans, obtain written approval from the Engineer.
5. Submit to the Engineer at least 1 ft² (0.1 m²) of the sign material for each lot or shipment of each type.

B. Fabrication

1. Make the extruded panel signs as shown on the Plans.
2. Finish the extruded panels as specified in Subsection 912.2.01.B.4.

C. Acceptance

The Department will accept these sign panels based on results of chemical and physical tests of materials, approval of methods and procedures for metal treatment, and the quality of workmanship on the finished panel.

D. Materials Warranty

General Provisions 101 through 150.

Section 925—Traffic Signal Equipment

Delete Section 925 and substitute the following:

925.1 General Description

This section provides Specifications for a variety of traffic signal equipment. Ramp Meters are defined as a form of traffic signalization and all general provisions for traffic signalization are applicable unless otherwise noted in the Plans and Specifications.

925.1.01 Related References

A. Standard Specifications

- Section 500—Concrete Structures
- Section 639—Strain Poles for Overhead Sign and Signal Assemblies
- Section 647—Traffic Signal Installation
- Section 682—Electrical Wire, Cable and Conduit
- Section 833—Joint Fillers and Sealers
- Section 861—Piling and Round Timber
- Section 870—Paints (Field Painting)
- Section 915—Mast Arm Assemblies
- Section 922—Electrical Wire and Cable
- Section 923—Electrical Conduit
- Section 926—Wireless Communication Equipment
- Section 935—Fiber Optic System
- Section 937 – Video Detection System
- Section 939—Communications and Electronic Equipment

B. Referenced Documents

- National Electrical Manufacturers Association (NEMA) Standards Publication TS 1 Section 15
- NEMA Standard Publication TS 2- 1998
- Institute of Transportation Engineers (ITE)Vehicle Traffic Control Signal Heads Specification
- ITE Vehicle Traffic Control Signal Heads: Light Emitting Diode (LED)Circular Signal Supplement June 27, 2005 Specification
- ITE Vehicle Traffic Control Signal Heads – Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules Specification
- ITE Pedestrian Traffic Control Signal indications – Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules Specification
- International Municipal Signal Association (IMSA) #20-1 Specification
- IMSA #20-4Specification
- IMSA #20-6Specification
- IMSA #50-2Specification
- IMSA #51-1Specification
- Underwriters Laboratory Inc. (UL) 94 Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

- UL 493 Standard for Safety for Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables
- Traffic Signal Control Equipment Specifications, January 1989 edition and applicable addenda, State of California Business, Transportation & Housing Agency
- State of California Department of Transportation (CALTRANS) Qualified Products List (QPL) Controller Assemblies for the Model 170/2070 Traffic Controller,
- CALTRANS Transportation Electrical Equipment Specifications (TEES) August 16, 2002 and applicable addenda
- CALTRANS Transportation Electrical Equipment Specifications (TEES) March 12, 2009 and applicable addenda
- Georgia Department of Transportation Qualified Products List 75“Polyurethane Sealant for Inductive Loops”(American Society of Testing and Materials(ASTM) A36 Standard Specification for Carbon Structural Steel
- Georgia Department of Transportation Qualified Products List
- ASTM A53 Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc-Coated, Welded and Seamless
- ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coating on Iron and Steel Products
- ASTM A153 Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
- ASTM A325 Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
- ASTM A475 Standard Specification for Zinc-Coated Steel Wire Strand
- ASTM A572 Standard Specification for High- Strength Low-Alloy Columbium-Vanadium Structural Steel
- ASTM C1028 Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method
- ASTM D256 Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
- ASTM D638 Standard Test Methods for Tensile Properties of Plastics
- ASTM D785 Standard Test Method for Rockwell Hardness of Plastics: Electrical Insulating Materials
- ASTM D790 Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- ASTM D2444 Standard Test Methods for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup
- ASTM D543 Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
- Electronic Industries Standards (EIA)

925.2 Materials

925.2.01 General

A. Requirements

Ensure that the traffic signal equipment and materials meet the Plans and Specifications.

All equipment furnished shall be new and meet the requirements of the following:

- Underwriter’s Laboratory Incorporated (UL)
- Electronic Industries Association (EIA)
- National Electric Code (NEC)
- American Society of Testing and Materials (ASTM)
- American National Standards Institute (ANSI)
- International Municipal Signal Association (IMSA)
- National Electrical Manufacturers Association (NEMA)
- Applicable Standards, Specifications, and Regulations of the:
 Georgia Department of Transportation
 Traffic Signal Electrical Facility & NaviGator Support (TSEF)
 935 E. Confederate Avenue, Building 24
 Atlanta, GA 30316

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

- Provide to the District Signal Engineer or maintaining agency all manufacturers' warranties and guarantees for all signal equipment items listed in this document as well as any signal equipment listed in the Plans, except for state supplied equipment.
- Ensure that warranties and guarantees are consistent with those provided as customary trade practices; or as otherwise specified in the Plans, Standard Specifications, Supplemental Specifications or Special Provisions.
- Ensure, and state, that manufacturer's and supplier's warranties and guarantees are transferable to the agency or user that is responsible for traffic signal maintenance. And said warranties and guarantees are continuous throughout their duration.
- Ensure equipment provided under this specification shall be warranted by the manufacturer to be free from defects in materials and workmanship for a minimum period of two years from date of receipt or one year from date of acceptance of installation. The exception is the other materials stated in this specification which have longer warranty durations.
- Ensure the manufacturer will repair any faulty equipment during this period at no charge to the Department for parts, labor or shipping to and from the factory.

925.2.02 Type 2070 Controller Assemblies

A. Requirements

For 2070 controller cabinet assemblies, use 2070 controller units that meet the requirements of the following or are previously approved by TSEF:

- *Traffic Electrical Equipment Specifications (TEES)* published by the State of California Business, Transportation, and Housing Agency; Department of Transportation, current edition and current addenda
- *CALTRANS Qualified Products List (QPL)*
- *GDOT Qualified Products List (QPL)*
- Ensure the unit supplied is compatible with current GDOT licensed firmware.

The following Specifications augment the CALTRANS Specifications and take precedence over conflicting CALTRANS Specifications.

1. Input/output (I/O) and Configuration:

The 2070 Controller shall be supplied in one of the following configurations, as specified in the Plans (all modules are specified in TEES, but these configurations supersede the defined configurations in TEES):

- 2070L: Provide Chassis, 2070-1B Single-Board CPU, 2070-2A Field I/O Module, 2070-3B Front Panel (8x40 display), 2070-4B 3.5-amp Power Supply, and a 2070-7A Module. This unit is intended for interfacing in Type 170E or ITS cabinets and shall provide the default input and output configuration as shown in Tables 925-13, 925-15 and 925-16 for ITS cabinets using a traffic signal application.
- 2070E: Provide Chassis, 2070-1E Single-Board CPU, 2070-2A Field I/O Module, 2070-3B Front Panel (8x40 display), 2070-4B 3.5-amp Power Supply, and a 2070-7A Module. This unit is intended for interfacing in Type 170E or ITS cabinets and shall provide the default input and output configuration as shown in Tables 925-13, 925-15 and 925-16 for ITS cabinets using a traffic signal application.
- 2070LC: Provide Chassis, 2070-1B Single-Board CPU, 2070-2B Field I/O Module, 2070-3B Front Panel (8x40 display), 2070-4B 3.5-amp Power Supply, and a 2070-7A Module. This unit is intended for interfacing in ITS cabinets only and shall provide the default input and output configuration as shown in Tables 925 -13, 925-15 and 925-16 for ITS cabinets using a traffic signal application.
- 2070 LB: Provide Chassis, 2070-1B Single –Board CPU, 2070-2A Field I/O Module, 2070-3C Front Panel, 2070-4B 3.5-amp Power Supply, This unit is intended for interfacing in Type 170E or ITS cabinets where a user interface is not required and shall provide the default input and output configuration as shown in Tables 925 -13, 925-15 and 925-16 for ITS cabinets using a traffic signal application.

- 2070 LN1: Provide Chassis, 2070-1B Single-Board CPU, 2070-2B Field I/O Module, 2070-3B Front Panel (8x40 display), 2070-4NB 3.5-amp Power Supply, 2070-8 NEMA Interface Module, and a 2070-7A Module. This unit is intended for interfacing in NEMA TS 1 or NEMA TS 2 Type 2 cabinets.
 - 2070 LN2: Provide Chassis, 2070-1B Single-Board CPU, 2070-2N Field I/O Module, 2070-3B Front Panel (8x40 display), 2070-4NB 3.5-amp Power Supply, and a 2070-7A Module. This unit is intended for interfacing in a NEMA TS 2 Type 1 cabinet.
 - 2070 LX: Provide Chassis, 2070-1C Single-Board CPU, 2070-2A Field I/O Module, 2070-3B Front Panel (8x40 display), and a 2070-4B 3.5-amp Power Supply. This unit is intended for interfacing in Type 170E or ITS cabinets and shall provide the default input and output configuration as shown in Tables 925-13, 925-15 and 925-16 for ITS cabinets using a traffic signal application
2. Power Supply Modules:
Either the 2070-4A, 2070-4B, 2070-4NA or 2070-4NB module shall be provided as required in the configuration requirements in the preceding Item. In addition to all requirements of the TEES, the power supplies shall be clearly marked as a “2070-4A”, “2070-4B”, “2070-4NA”, or “2070-4NB”. The Vendor may supply a 2070-4A or 4NA power supply module in lieu of a 2070-4B or 4NB, as long as it is so marked and adds no additional cost to GDOT.
 3. Documentation:
Include with each controller, manuals that document the programming, operation, and maintenance of the unit. Include schematic drawings and pin assignment charts in the manuals for maintenance. Documentation shall include all components, including communications modules. Specific reference is made to section 1.2.4 Documentation in the CALTRANS TEES concerning required documentation to be provided.
 4. Testing:
Provide for complete testing of unit before it is shipped. If unit is shipped with applications firmware installed, it must be tested with the application (e.g. Traffic Signal Control). If a random sample of greater than 10 percent of the units tested is rejected then the total shipment shall be rejected and vendor will be responsible for all costs to test and repair all units provided.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

See Subsection 925.2.02 for compliance with CALTRANS QPL. Also see item 4 Testing in Section A above.

D. Materials Warranty:

(See Subsection 925.2.01 D for Materials Warranties).

925.2.03 Type 2070 Controller Subassemblies

A. Requirements

For 2070 controller subassemblies, use 2070 controller subassembly units that meet the requirements of the following or are previously approved by TSEF:

- *Traffic Electrical Equipment Specifications (TEES)* published by the State of California Business, Transportation, and Housing Agency; Department of Transportation, current edition and current addenda
- CALTRANS Qualified Products List (QPL)

The following Specifications augment the CALTRANS Specifications and take precedence over conflicting CALTRANS Specifications.

1. 2070 1B Module:
The 2070 1B module may be supplied as a separate item to be used in all versions of the 2070 controller. The 2070 1B module shall be supplied complete with the operating software. Ensure it contains the required files to be compatible with the current GDOT applications software.
2. 2070 1E Module:
The 2070 1E module may be supplied as a separate item to be used in all versions of the 2070 controller. The 2070 1E module shall be supplied complete with operating software. Ensure it contains the required files to be compatible with the current GDOT applications software.
3. 2070 1C Module:

The 2070 1C module may be supplied as a separate item to be used in all versions of the 2070 controller. The 2070 1C module shall be supplied complete with operating software. Ensure it contains the required files to be compatible with the current GDOT applications software.

4. 2070 2A Field I/O Module

The 2070 2A Field I/O module may be supplied as a separate item. The 2070 2A Field I/O module shall consist of the Field Controller Unit; Parallel Input/Output Ports; other Module Circuit Functions (includes muzzle jumper); Serial Communication Circuitry; Module Connectors C1S, C11S and C12S mounted on the module front plate; VDC Power Supply (+12VDC to +5VDC) and required software. Ensure it contains any configuration jumpers to be compatible with current GDOT Applications software. Ensure the 2070 2A field I/O Module functions with a Model 2070L or 2070LB Controller Assembly and is compatible with current GDOT applications software.

5. 2070 2B Field I/O Module:

The 2070 2B Field I/O module may be supplied as a separate item and consist of the Serial Communication Circuitry, DC power Supply, and Module Connector 12S mounted on the module front plate only. Ensure it contains any configuration jumpers to be compatible with current GDOT Applications software. Ensure the 2070 2B field I/O Module functions with a Model 2070 LC or 2070LN1 Controller Assembly and is compatible with current GDOT applications software.

6. 2070 2N Field I/O Module:

The 2070 2N Field I/O module may be supplied as a separate item and provides a NEMA TS2-1 compatible SDLC interface via Serial Port 3. AC power to the 2070 Unit and Fault Monitor Logic Output via 2070 Serial Port 5 and Output Frame Byte 9 Bit 6 to the NEMA TS2 Cabinet Monitor Unit (CMU). Ensure it contains any configuration jumpers to be compatible with current GDOT Applications software. Ensure the 2070 2N field I/O Module functions with a Model 2070 LN2 Controller Assembly and is compatible with current GDOT applications software.

7. 2070 3B Front Panel Display Module:

The 2070 3B Display Module may be supplied as a separate item and provides a Front Panel Assembly controller, two keyboards, AUX switch alarm bell and an 8 line by 40 character display. This assembly shall also include a panel with latch assembly and two TSD #1 hinge attaching devices, assembly PCB, external serial port connectors, CPU active LED indicator, contrast adjustment knob, and Front Panel Harness. Ensure it contains any configuration jumpers to be compatible with current GDOT Applications software. Ensure the 2070 3B Front Panel Assembly Module functions with Models 2070L, 2070LC, 2070LN1 and 2070 LN2 Controller Assemblies and is compatible with current GDOT applications software. Ensure the hardware hinge attaching devices mate with existing 2070 assemblies. Ensure the Front Panel Harness is connected to the front panel via a removable connector. Ensure the front panel connector supports the aux switch.

8. 2070 3C Front Panel Display Module:

The 2070 3C Display Module may be supplied as a separate item and provides a System Serial Port 6 Lines, Isolated and vectored to Connector C60S. This assembly shall also include a panel with latch assembly and two TSD #1 hinge attaching devices, assembly PCB, external serial port connectors, CPU active LED indicator, and Front Panel Harness. Ensure it contains any configuration jumpers to be compatible with current GDOT Applications software. Ensure the 2070 3B Front Panel Assembly Module functions with Model 2070LB Controller Assembly and is compatible with current GDOT applications software. Ensure the hardware hinge attaching devices mate with existing 2070 assemblies. Ensure the Front Panel Harness is connected to the front panel via a removable connector. Ensure the front panel connector supports the aux switch.

9. 2070 4B Power Supply Module:

The 2070 4B Power Supply Module may be supplied as a separate item and is an independent, self-contained module. Ensure that it is vented and cooled by convection only. Provide module that slides into power supply compartment from the back of the chassis and is attached to the Backplane mounting surface by its four TSD #3 Devices. Ensure the module supplies at least 3.5 amperes of +5VDC. Ensure the 2070 4B Power Supply Module is compatible with Models 2070L, 2070LB, and 2070LC Controller Assemblies and is compatible with current GDOT applications software. Ensure the connection harness PS 2 on existing units can be mated with the 4B module supplied. A 2070 4A Power Supply Module may be provided in place of a 4B module as long as it is labeled as such and there is no additional cost to GDOT. Ensure the module supplied is appropriately marked as a 4B or 4A module.

10. 2070 4NB Power Supply Module:

The 2070 4NB Power Supply Module may be supplied as a separate item and is an independent self-contained module. Ensure that it is vented and cooled by convection only. Provide module that slides into power supply compartment from the back of the chassis and is attached to the Backplane mounting surface by its four TSD #3 Devices. Ensure the module supplies at least 3.5 amperes of +5VDC. Ensure the 2070 4B Power Supply Module is

compatible with Models 2070 LN1 and 2070 LN2 Controller Assemblies and is compatible with current GDOT applications software. Ensure the connection harness PS 2 on existing units can be mated with the 4B module supplied. Ensure the 4NB power supply module supports the NEMA TS1 and TS2 Standards. A 2070 4A Power Supply Module may be provided in place of a 4B module as long as it is labeled as such and there is no additional cost to GDOT. Ensure the module supplied is appropriately marked as a 4NA or 4NB module.

11. 2070 6B Communications Module:

The 2070 6B Communications Module is supplied as a separate item. The 6B communications module is a dual async/modem serial module. Ensure the module supports both Serial and modem FSK communications on both of two separate ports. Ensure the Modem data baud rate supports 0 to 9600. Ensure the module is configured to support FSK communications on the C2S connection. Ensure it contains any configuration jumpers to be compatible with current GDOT Applications software.

12. 2070 7A Communications Module:

The 2070 7A Communications Module may be supplied as a separate item. The 7A communications module is a dual async serial communications module. Ensure the module supports serial communications on both ports. Ensure it contains any configuration jumpers to be compatible with current GDOT Applications software.

13. 2070 8 Field I/O Module:

The 2070 8 Field I/O Module may be supplied as a separate item. The 8 Field I/O Module consists of the module chassis, module power supply, Field Control Unit Controller, parallel input/output ports, serial communications circuits and module connectors. Ensure the EX1 connector is provided with appropriate mating connections to interface with either 6B or 7A communications modules. Ensure the 2070 8 Field I/O module is provided with the appropriate mating connector to mate with the C12S connector on the 2070 2B Field I/O module. Ensure the 2070 8 Field I/O module functions as part of a Model 2070 LN1 controller.

14. 2070 D Panel:

The 2070 D panel is supplied as a separate item. The 2070 D panel supports the inputs and outputs of the “D” connector provided on a 2070-8 module which is also part of a Model 2070 LN1. Ensure the “D” Connector panel supports all 61 pins with a connecting MS “D” connector and terminal blocks. Ensure the 2070 D Panel provides adequate cable length to allow attachment in an existing NEMA Cabinet. Ensure that the terminal blocks allow for two connections.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

(See Subsection 925.2.02 for compliance with CALTRANS QPL.)

D. Materials Warranty:

(See Subsection 925.2.01.D for Materials Warranties.)

925.2.04 Cabinet Assemblies

A. Requirements

In addition to the CALTRANS Specifications, ensure that the cabinet assembly conforms to the requirements listed below, which take precedence over conflicting CALTRANS Specifications.

1. Cabinet configuration:

Supply cabinets in accordance with these Specifications. Equip the cabinets with auxiliary equipment as follows:

a. Model 332 Cabinet:

Lower input field termination panel

1 – Model 242 DC Isolator in Slot 14 of Upper Input File

4 – Flash Transfer Relays

2 – Model 204 Flashers

1- 4 Position Power Strip

1- Manual push button assembly

1- Auxiliary Output File

b. Model 336S Cabinet:

- 1-Model 242 DC Isolator in Slot 14 of Input File
- 4- Flash Transfer Relays
- 2-Model 204 Flashers
- 1- 4 Position Power Strip
- 1- Manual push button assembly
- 1-"M" Base Adapter installed (Base Mount Cabinets Only)
- 1-Aluminum Cover Plate for Cabinet Bottom (Pole Mount Cabinets Only)
- c. Model 337 Cabinet
 - 3-Flash Transfer Relays
 - 1-Model 204 Flasher
 - 1- Manual push button assembly
- d. Model 334 Cabinet with Auxiliary Output File for Ramp Metering Operations
 - 1- Output/PDA Type 3 with Model 206 24 Volt DC Power Supply with flash transfer relay
 - 1- Model 208 Monitor Unit
 - 1-Load Switch Model 200
 - 1- 4 Position Power Strip
 - 1- Lower Input Field Termination Panel
 - 1- Detector Test Switch Panel

<p>NOTE: Include above components in cabinet at time of delivery.</p>
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Other auxiliary cabinet components such as controllers, monitors, load switches, etc. will be ordered as separate items.

2. Finish

Use cabinets that have a bare aluminum finish (see Subsection 925.2.04.B.1 for controller-cabinet minimum fabrication Specifications).
3. Locks

Equip the main cabinet door with locks that accept No. 2 Corbin keys. Provide two sets of keys with each cabinet. One set of keys is defined as one – No. 2 key and one - police panel key.
4. Power

Equip the cabinet assemblies with a power distribution assembly to generate AC and DC power for the electronic components, except the DC power for the controller units. Provide the Model 332 and 336S cabinets with a DC isolator for stop time/flash sense, located in slot 14 of the input file.
5. Mounting

Equip the cabinets for pole or base mounting, as specified in the Plans.

 - a. Base Mount

Supply Model 336S cabinets, when specified as base mount, with an “M” base-mounting adapter installed.
 - b. Pole Mount

Supply Model 336S or 337 cabinets, when specified as pole mount, with two exterior pole mounting brackets that allow for mounting on steel, concrete, and timber poles.

Ensure that the bracket mounting holes are properly reinforced with metal plates of adequate size and strength, welded longitudinally across the inside depth of the cabinet.

Ensure that the exterior-mounting bracket is shipped installed on the cabinet housing. Additionally, provide an aluminum plate, which covers the bottom cabinet opening.
6. Unused Phase Monitoring

Provide odd-phase reds with ballast resistor (2K, 10 watt) dummy loads. Do not wire the cabinet to monitor pedestrian yellow indications. When auxiliary output file is used provide resistors for overlaps.

Neatly lace, label and bundle the wiring from the signal monitor for pedestrian yellow monitoring on the back panel.
7. Red Monitoring

Provide a connector and terminal assembly designated as P20 for monitoring the absence of red as an integral part of the output file. Terminate the connector and ensure compatible with the cable and C connector of a Type 2010 conflict monitor unit capable of monitoring the absence of red.

Provide the pin assignments of the P20 connector and terminal assemble with the cabinet Plans.

Ensure that the P20 connector is physically alike to the cable and connector of a Type 2010 conflict monitor unit to prevent the absence of red cable connector from being inserted into the P20 connector 180 degrees out of alignment. Submit details for programming of the unused red channels for approval.

8. Cabinet Light

Include in each cabinet one fluorescent strip lighting fixture mounted inside the top front portion of the cabinet. Do not use screw in type fluorescent lamp. LED cabinet lighting is acceptable as an alternative provided it supplies an equivalent amount of light as the fluorescent installation.

The fixture includes a cool white lamp, covered, and operated by a normal power factor, UL listed ballast.

Install a door-actuated switch to turn on the cabinet light when either door is opened.

Cabinet fan and light shall be fed from 15 amp equipment breaker.

9. Cabinet Interlock

Do not install the interlock circuit, as detailed in the CALTRANS Specifications.

10. Laptop Shelf

Equip each Model 334, 332, and 336S cabinet with a hinged aluminum shelf and integrated storage compartment mounted on the front door, inside the cabinet assembly. To allow proper ventilation throughout the cabinet, a sliding shelf/drawer shall not be mounted in the rack assembly. The shelf shall have a smooth, non-slip surface, sufficient for use as a writing platform and of sufficient size and stability to support a typical laptop computer when extended. The shelf shall have rounded or insulated edges that do not have the potential to harm the user. The shelf shall lock into place when folded for storage. Locking the shelf for storage and/or extending it for use shall not require the use of any tool.

11. Red Enable Board Cover

The Output File Assembly shall implement a hinged, clear, polycarbonate cover to protect the Red Enable Board during normal operation. This cover shall be hinged on the left or right side. When closed, the side opposite the hinged shall be secured to the Output File Assembly without the use of any hardware or tool. When fully opened, the cover shall not inhibit the removal, replacement or configuration of the Red Enable Board. Removal and replacement o the Red Enable Board shall not require the removal of the protective cover.

12. Power Strip

Equip each cabinet with a metal power strip (minimum of 4 outlets) to support AC power for external communications devices in cabinet. Provide metal strip that is mounted vertically on the rear rail. Ensure that the power strip may be used by block power supplies such that the block power supply does not block other outlets. Attach power strip to a permanent location that is easily accessible to devices in the rear of the cabinet. Provide hard wire connection to the Cabinet AC power, controlled by a 15 amp breaker. Do not use plug in power strips.

13. Surge Protection

Equip each cabinet with devices to protect the control equipment from surges and over voltages.

Design the surge protector panels to allow for adequate space for a wire connection and surge protector replacement without the removal of terminal blocks or panels. Provide surge protectors for the input sections as detailed below and as shown in the Input Terminal and Surge Arrestor Detail.

Supply surge protectors that meet the following Specifications.

a. AC Service Input

- Include a surge protection unit for each cabinet on the AC service input that meets or exceeds the following requirements: Provide a hybrid type power line surge protection device on the cabinet service panel.
- Install the protector between the applied line voltage and earth ground.
- Use a surge protector capable of reducing the effect of lightning transient voltages applied to the AC line that conforms to the following:

Peak surge current for an 8 x 20 μ s waveform:	20,000A for 20 occurrences
Clamp voltage @ 20,000A:	280V max
Maximum continuous operating current:	@ 120V / 60 Hz 10A

Series Inductance:	AC Line/AC Neutral - 200 micro henries
Response time:	Voltage never exceeds 280V during surge
Spike suppression for +/- 700 V spike:	+/- 40 V deviation from sine wave at all phases Angles between 0 and 180 degrees.

- Provide a protector that is modular and uses a 12 pin Beau connector with the following terminals:
 - Main Line (AC line first stage terminal)
 - Main Neutral (AC neutral input terminal)
 - Equipment Line In (AC line second stage input terminal, 10A)
 - Equipment Line Out (AC line second stage output terminal, 10A)
 - Equipment neutral out (neutral terminal to protected equipment)
 - GND (Earth connection)
- Supply a protector that is epoxy encapsulated in a flame-retardant material.
- Configure the Equipment Line Out to provide power to the Type 2070 and to the 24 V power supply.

b. AC+ Interconnect Cable Inputs

Use a surge protection device to protect each AC interconnect line as it enters the cabinet with a surge protection device that meets or exceeds the following requirements:

- 3-electrode gas tube type of surge arrestor
- Striking voltage of 300-500 V DC with a minimum holder over voltage of 155V DC
- A three terminal device, one of which is connected to ground, the other two are connected across each input respectively
- The units must meet the following minimum requirements:

Impulse breakdown:	Less than 100V in less than 1.1 μ s at 10 kV/ μ s
Impulse breakdown balance:	0.01 microsecond (or less) difference at 10 kV/ μ s impulse
Energy application:	Withstands 20A AC for one (1) second applied ten (10) times at three (3) minute intervals on either section
Current rating:	10,000A (8 x 20 μ s impulse)
Capacitance:	6 pF, line to ground

c. Inductive Loop Detector Inputs

Provide surge arrestors in the cabinet as shown in Table 925-5, Table 925-7 or Table 925-9 for the applicable cabinet. Protect each inductive loop detector channel input by an external surge protection device that meets or exceeds the following requirements:

- A three-terminal device, two (2) of which are connected across the signal inputs of the detector with the third connected to the chassis ground to protect against common mode damage.
- Instantly clamps differential mode surges (induced voltage across the loop detector input terminals) via a semiconductor array. The array appears as a low capacitance to the detector.
- Clamps common mode surges (induced voltage between the loop leads and ground) via solid state clamping devices.
- Withstand 25-100A surge current occurrences of a 10 x 700 μ s waveform.
- Have the following clamp characteristics:

Maximum break over voltage:	170 V
Maximum on-stage clamping voltage:	3V
Response Time:	<5 ns
Off-stage leakage current:	<10 μ A
Capacitance:	less than 220 pf
- Ensure that the unit also meets the following minimum requirements:

Peak surge current:	6 times
Differential mode:	400 A (8 x 20 ms)
Common mode:	1,000 A (8 x 20 ms)

Estimated occurrences:	500 @ 200 A
Response time:	40 ns
Input capacitance:	35 pF typical
Temperature:	-40° F to +185° F (-40° C to 85° C)
Mounting:	No. 10-32 x 3/8-inch (No. 5 x 10 mm) bolt
Clamp voltage @400 A diff.	Mode: 30 V max.
Clamp voltage @1,000 A comm.	Mode: 30 V max.

d. Signal Load Switches (Switchpacks)

Provide the output of all switchpacks in all output files and output/PDAs with metal oxide varistors (MOV) tied from the AC positive field terminal to the chassis ground to protect switchpacks from surges on the AC output lines

Ensure that these MOVs meet or exceed these requirements:

- Steady state sinusoidal voltage (RMS) rating at 50 to 60 Hz of at least 150 V at 77 °F (25 °C)
- Steady state applied DC voltage rating of at least 200 V at 77 °F (25 °C)
- Transient energy rating is of at least 80 J for a single impulse of 10/1,000 μ s current waveform at 77 °F (25 °C)
- Peak current rating of 6,500 A for a single impulse of 8/20 μ s waveform with the rated continuous voltage applied
- Varistor voltage of at least 212 V at 1.0mA of DC current applied for the duration of 20 μ s to 5s
- Clamping voltage of at least 395 V with an applied 8/20 μ s impulse of 100 A
- Typical capacitance at a frequency of 0.1 to 1.0 MHz of 1600 pF
- Two-terminal device, one of which is connected to the AC output of the signal load switch on the output file terminals (backside of the field terminals) with the other connected to AC neutral

e. Communication Inputs

Protect low voltage communications input as it enters the cabinet with a solid-state surge protection unit that meets or exceeds these requirements:

- Dual pair (4-wire) module with a printed circuit board connector, double sided and gold plated for reliability
- Ability to mate with and be installed in a 10-circuit Buchanan connector Part Number PCB1B10S or Tyco Part Number 2-1437410-3 or equivalent
- Usable as two independent signal pairs
- The data circuits pass through the protection in a serial fashion
- C2 connector of the 2070 controller that terminates on the line side of the unit
- Communication field wires for this local side that terminate on the line side of the unit
- Ground terminals connected to power ground
- Ensure that the unit meets the following minimum requirements:

Peak surge current:	10 kA (8 x 20 μ s wave shape)
	500A (10 x 700 μ s wave shape)
Occurrences @ peak:	50 typical
Response time:	<1ns
Voltage Clamp:	8V line to line
Series Resistance:	24 Ω total
Temperature:	-40 °F (-40 °C) to +185 °F (85 °F)
Primary protector:	3 element gas tube 5kA, (8 x 20 μ s wave shape), per side
Secondary protector:	Silicon avalanche, 1.5 kW minimum

f. Low Voltage DC Inputs

Provide an external surge protection device for each low voltage DC input channel which meets the same requirements as the communication inputs with the following exception of the Voltage clamp, which shall be 30 V line-to-line.

14. Type 2010 Signal Monitors:

a. Introduction

This Specification sets forth the minimum requirements for a rack-mountable, sixteen channel, solid-state 2010 Signal Monitor for Traffic Cabinet Assembly. Ensure that as a minimum, the Signal Monitor complies with all Specifications outlined in Chapter 3 Section 6 of the *California TEES*, August 2002. Where differences occur, this Specification governs. Ensure that the manufacturer of the unit is listed on the current California Department of Transportation (CALTRANS) Qualified Products List (QPL) for signal monitors as well as the GDOT QPL.

Provide a Signal Monitor that is capable of monitoring sixteen channels consisting of a Green input, a Yellow input, and a Red input for each channel. Ensure that the unit also includes the enhanced monitoring functions described in Subsection 925.2.04.A.15.

b. Monitor Functions

Except for Conflict faults, compute all fault timing for each channel individually.

1) Conflict Monitoring

Ensure that the Signal Monitor is able to detect the presence of conflicting green or yellow signal voltages on the AC field terminals between two or more non-compatible channels. A Conflict fault (CONFLICT) shall be a latching fault.

2) Conflict Recognition Time

Ensure the Signal Monitor shall trigger when voltages on any conflicting channels are present for more than 500 ms. Ensure that the Signal Monitor does not trigger when voltages on any conflicting channels are present for less than 200 ms. Conflicting signals sensed for more than 200 ms and less than 500 ms may or may not trigger the unit.

3) 24VDC Monitoring VDC

Ensure that the Signal Monitor is able to detect that the cabinet +24 Vdc supply has fallen below 18 Vdc. A 24VDC failure (VDC FAIL) shall be a latching fault.

4) 24VDC Recognition Time

Ensure that the Signal Monitor shall trigger when the voltage on the +24V input is below 18 Vdc for more than 500 ms. Ensure that the Signal Monitor does not trigger when the voltage on the +24V input is below 18 Vdc for less than 200 ms. A voltage level of +22 Vdc will be required to prevent the unit from triggering.

5) Controller Watchdog Monitoring

Ensure that the Signal Monitor triggers when the Watchdog input does not toggle within the programmed time period (WDT ERROR). Ensure that the unit remains latched in the fault state until reset by the Reset button, an External Reset input command, or AC Line voltage restoring from an AC Line Brownout event. Ensure that a reset resulting from an AC Line Brownout event does not clear the WDT ERROR LED.

a) Controller Watchdog Latch Option

Ensure a programming option sets the Watchdog monitoring function to a latching mode and that only a reset from the Reset button or External Reset input can clear a Watchdog fault. An AC Line brownout condition will not reset the fault.

b) Controller Watchdog Recognition Time

Ensure a programming option sets the maximum Watchdog recognition time to: 1000 + or - 100 ms; or 1500 + or - 100 ms.

c) Controller Watchdog Enable Switch

Provide an internal switch to disable the Watchdog monitoring function. Mount the switch on the PCB and be clearly label "WD ENABLE - ON...OFF". Ensure that placement of the switch in the OFF position causes monitoring of the Watchdog to be inhibited.

d) WDT ERROR LED Control

Ensure that the WDT ERROR LED illuminates when the unit has been triggered by a Watchdog fault. Ensure that it can only be cleared by a reset command from the front panel Reset switch or External

Reset input. If the Watchdog monitoring function is inhibited due to the Watchdog Enable switch, the WDT ERROR LED shall flash at a 0.5 Hz rate.

6) AC Line Monitoring

a) AC Line Brownout Recognition

Ensure that the Signal Monitor is able to detect that the AC Line has fallen below 98 + or - 2 Vac for greater than 400 + or - 50 ms. This shall force the output Relay to the de-energized "fault" state, enable the Stop-Time output, and cause the AC POWER LED to flash at a 2 Hz rate. Ensure that the unit maintains this state until the AC Line voltage rises above 103 + or - 2 Vac for greater than 400 + or - 50 ms. Provide a jumper option which will change the AC Brownout dropout level to 92 + or - 2 Vac and the restore level to 98 + or - 2 Vac.

b) AC Line Power-up and Brownout Delay Time

When the AC Line is greater than 103 + or - 2 volts after power-up or Brownout restore, ensure that the Signal Monitor holds the Output Relay in the de-energized "fault" state and enable the Stop-Time output, for a period of not less than 6.0 + or - 0.5 seconds and not greater than 10.0 + or - 0.5 seconds. Ensure that this flash interval is terminated after at least 6.0 + or - 0.5 seconds if the Signal Monitor has detected at least five transitions of the Watchdog input. If the Signal Monitor does not detect five transitions of the Watchdog input before 10.0 + or - 0.5 seconds, ensure that the Signal Monitor goes to the fault state. During this interval, ensure that the AC POWER LED flashes at a 4 Hz rate.

7) Red Fail Monitoring

Ensure that the Signal Monitor is able to detect the absence of an active voltage on the green and yellow and red field signal inputs of a channel. Red Fail fault (RED FAIL) shall be a latching fault. Ensure that the Red Fail monitoring function is enabled for all channels except when the Red Enable input is not active, or pin #EE is active, or Special Function #1 input is active, or Special Function #2 input is active.

a) Red Fail Recognition Time

Ensure the Signal Monitor triggers when an active voltage on one of the three inputs of a channel are absent for more than 1500 ms. Ensure that the Signal Monitor does not trigger when an active voltage on one of the three inputs of a channel are absent for less than 1200 ms. Channels without proper voltages sensed for more than 1200 ms and less than 1500 ms may or may not trigger the unit. Provide an option switch (RF 2010) which will change the fault recognition time to between 700 ms and 1000 ms.

b) Red Interface Cable Fault

Ensure a programming option is provided such that operating without the Red Interface cable installed shall cause the Signal Monitor to enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. To indicate this fault mode, ensure that the Red Fail indicator is illuminated with all fault channel indicators Off.

Ensure that any Red Fail preemption control to the monitor uses the Special Function inputs #1 or #2.

8) Dual Indication Monitoring

Ensure that the Signal Monitor is able to detect the presence of active voltage on the green and yellow, green and red, or yellow and red field signal inputs of a channel. GYR Dual Indication fault (DUAL IND) shall be a latching fault. Ensure this function is enabled on a per channel basis using dip switches mounted on the PCB labeled "CH1" through "CH16". Ensure that the GYR Dual Indication monitoring function is enabled for all selected channels except when the Red Enable input is not active or pin #EE is active.

a) GY Dual Indication Monitoring

Ensure that the Signal Monitor is able to detect the presence of active voltage on the green and yellow field signal inputs of a channel. GY Dual Indication fault (DUAL IND) shall be a latching fault. Enable this function with a dip switch on the PCB labeled "GY ENABLE". When the switch is in the ON position, monitor all channels for simultaneous active green and yellow inputs on a channel. When selected by the GY ENABLE switch, ensure that the GY Dual Indication monitoring function is disabled when pin #EE is active.

b) Dual Indication Recognition Time

Ensure that the Signal Monitor triggers when multiple inputs are active on a channel for more than 500 ms. Ensure that the Signal Monitor does not trigger when multiple inputs are active on a channel for less than 250 ms. Channels with multiple voltages active for more than 250 ms and less than 500 ms may or may not trigger the unit.

9) Clearance (Short or Absent Yellow) Monitoring

Ensure that the Signal Monitor is able to detect that a channel has not provided an adequate Yellow Clearance interval during a green to yellow to red sequence. A Sequence failure (SEQUENCE) shall be a latching fault. Ensure that this function is enabled on a per channel basis using dip switches mounted on the PCB labeled "CH1" through "CH16". Ensure that the Sequence monitoring function is enabled for all selected channels except when the Red Enable input is not active or pin #EE is active.

10) Clearance Recognition Time

Ensure that the Yellow Clearance interval is 2.7 seconds

11) Flickering Indication Detection

Ensure that the Signal Monitor provides a method of detecting Conflict, Red Fail, and Dual Indication faults that result from intermittent or flickering field signal inputs that may not meet the duration requirements but continue to flicker for an extended period of time. These flickering indications shall result in a latching fault with an indication illuminated along with the resulting Conflict, Red Fail, or Dual Indication indicator. Provide an option switch to disable this option.

12) Configuration Change Monitoring

- On power-up, reset, and periodically during operation, ensure that the Signal Monitor compares the current configuration settings with the previously stored value and if the settings have changed, the Signal Monitor automatically logs the new setting. Ensure that these settings include the permissive diode matrix, all switches, all jumpers, and the Watchdog Enable switch.
- Provide a programming option such that any change in the configuration parameters will cause the Signal Monitor to enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. To indicate this fault mode ensure that the PCA indicator will flash at a 4 Hz rate. Depressing the Reset button for 5 full seconds is required to clear this fault and log the new configuration parameters.
- If the programming option is not selected, ensure that the unit does not set the fault mode but will still log the configuration change.

13) Program Card Ajar

Ensure that when the Programming Card is removed or not seated properly, the Signal Monitor forces the Output Relay to the de-energized "fault" state, enable the Stop-Time output, and illuminate the PCA LED. A reset command from the front panel Reset switch or External Reset input is required once the Program Card is in place.

14) Exit Flash

When the Signal Monitor exits the flash state (Output relay de-energized) as a result of a Reset command or AC Line brownout restore, ensure that the Stop Time output goes to the inactive state 250 + OR - 50 ms before the Output relay transfers to the energized state. This transition will provide an early indication to the Controller Unit that the cabinet will transfer from flash to signal operation.

c. Display Functions

Ensure that it is possible to view the active channels for each individual color (GYR) during operation and when latched in a fault state. When the Signal Monitor is latched in a fault state ensure that it is also be possible to view the active channels for each individual color and fault status for each channel for the current fault and the two previous faults.

1) Previous Fault GYR Display

- When the Signal Monitor has been triggered by a fault the channel status display will alternate between the channels which were involved in the fault (fault status) for 2 seconds, and the field signals active at the time of the fault for 6 seconds. The channels involved in the fault will flash their respective Green, Yellow, and Red indicators simultaneously at a 4 Hz rate for the 2 second interval.
- The two previous faults may also be displayed individually. This status is not reset by an AC Line power interruption. To enter this display mode remove the Program Card. The sequence is as follows:

Reset	Event	PCA LED	Fault Status LEDs	Channel Status LEDs
---	#1	Single flash	Current Fault Status (newest)	Current Field status
#1	#2	Double flash	Event #2 Fault Status	Event #2 Field status
#2	#3	Triple flash	Event #3 Fault Status (oldest)	Event #3 Field status
(repeats back to top)				

d. Event Logging Functions

Ensure that the Signal Monitor is capable of storing in non-volatile memory a minimum of 100 events. Mark each event with the time and date of the event. These events consist of fault events, AC Line events, reset events, and configuration change events. Provide a graphical means of displaying the signal states of all field inputs for 30 seconds prior to a fault trigger event. Provide the capability to assign a four-digit identification number to the unit shall be provided. Upload the event logs to a PC using the serial port of the Signal Monitor and software provided by the manufacturer.

Ensure each event log report contains the following information:

- Monitor ID#: a four digit (0000-9999) ID number assigned to the monitor.
- Time and Date: time and date of occurrence.
- Event Number: identifies the record number in the log. Event #1 is the most recent event.

1) Monitor Status Report (CS)

Ensure the Current Status report contains the following information:

- Fault Type: the fault type description.
- Field Status: the current GYR field status and field RMS voltages if the monitor is not in the fault state, or the latched field status and field RMS voltages and fault channel status at the time of the fault.
- Cabinet Temperature: the current temperature if the monitor is not in the fault state, or the latched temperature at the time of the fault.
- AC Line Voltage: the current AC Line voltage if the monitor is not in the fault state, or the AC Line voltage at the time of the fault.
- Control Input Status: the current state and RMS voltages of the Red Enable input, EE input, and Special Function #1 and #2 inputs if the monitor is not in the fault state, or the status latched at the time of the fault.

2) Previous Fault Log (PF)

Ensure the Previous Fault log contains the following information:

- Fault Type: the fault type description.
- Field Status: the latched field status with RMS voltages, and fault channel status at the time of the fault.
- Cabinet Temperature: the latched temperature at the time of the fault.
- AC Line Voltage: the AC Line voltage at the time of the fault.
- Control Input Status: the latched state of the Red Enable input, EE input, and Special Function #1 and #2 inputs at the time of the fault.

3) AC Line Event Log (AC)

The AC Line log shall contain the following information:

- Event Type: describes the type of AC Line event that occurred.
 - Power-up—AC on, monitor performed a cold start
 - Interrupt—AC Line < Brownout level
 - Restore—AC restored from brown-out or interruption (AC Off), no cold start
- AC Line Voltage: the AC Line voltage at the time of the event.

4) Monitor Reset Log (MR)

Ensure the Monitor Reset log contains the following information:

The monitor was reset from a fault by the front panel Reset button or External Reset input.

5) Configuration Change Log (CF)

Ensure the Configuration Change log contains the following information:

- a) Program Card Matrix: the permissive programming for each channel.
- b) Yellow Disable Jumpers: the Yellow Disable programming for each channel.
- c) Dual/Sequence Switches: the switch programming for each channel.
- d) Option Switches: RF 2010, RP Disable, GY Enable, SF1 Polarity, Sequence Timing, Minimum Flash Enable, Configuration Fault Enable, Red Cable Fault enable, AC Brownout timing.
- e) Watchdog Programming: Watchdog Enable, Watchdog Latch, and Watchdog timing.
- f) Configuration CRC: A unique CRC value which is based on the configuration of items #a though #e above.

Indicate on the log, which items have been changed since the last log entry.

6) Signal Sequence Log

Provide a log that graphically displays all field signal states for up to 30 seconds prior to the current fault trigger event. Ensure that the resolution of the display is at least 50 milliseconds.

e. Communications Functions

1) Controller Unit Communications

Type A: Ensure that the Signal Monitor is compatible with the protocol of the current GDOT licensed firmware for 2070 controllers and Central System Control. Ensure the 2010 Conflict Monitor supplied is able to communicate via a serial link. to the 2010 Controller and then to a Central System using the current licensed GDOT Central System Software for reporting, configuring and logging.

Type B: Ensure that the Signal Monitor is compatible with the protocol of the current GDOT licensed firmware for 2070 controllers and Central System Control. Ensure the 2010 Conflict Monitor supplied is able to communicate via a RJ-45 connector (Ethernet).

2) Personal Computer Communications

Have the manufacturer provide software to access the Signal Monitor status and event logs described in Subsection 925.2.04.A.14.d. Ensure this software operates with current version of Microsoft Windows.

f. Hardware

1) Red Monitoring

a) Red Field Inputs

Ensure that the Signal Monitor is capable of monitoring sixteen Red field signals. Ensure that a Red input is sensed active when the input voltage exceeds 70 Vrms. Ensure that a Red input is sensed not active when the input voltage is less than 50 Vrms. A Red input may or may not be sensed active when the input voltage is between 50 Vrms and 70 Vrms.

b) Red Enable Input

Ensure that the Red Enable input provides an AC input to the unit which enables Red Monitoring, Dual Indication Monitoring, and Sequence monitoring when the input is sensed active.

Ensure that the Red Enable input is sensed active when the input voltage exceeds 70 Vrms. Ensure that the Red Enable input is sensed not active when the input voltage is less than 50 Vrms. The Red Enable input may or may not be sensed active when the input voltage is between 50 Vrms and 70 Vrms.

c) Special Function Preemption Inputs

Ensure that the Special Function Preemption inputs #1 and #2 provide an AC input to the unit which disables only Red Fail Monitoring (Lack of Output) when either input is sensed active.

Ensure that a Special Function input is sensed active when the input voltage exceeds 70 Vrms. Ensure that a Special Function input is sensed not active when the input voltage is less than 50 Vrms. A Special Function input may or may not be sensed active when the input voltage is between 50 Vrms and 70 Vrms.

Use a PCB mounted switch to provide the option to invert the active status of the Special Function #1 input. When the switch is in the ON position, ensure that the Special Function #1 input is sensed not active when the input voltage exceeds 70 Vrms. Ensure that the Special Function #1 input is sensed active when the input voltage is less than 50 Vrms. The Special Function #1 input may or may not be sensed active when the input voltage is between 50 Vrms and 70 Vrms.

d) Red Interface Connector

This connector provides the required inputs for the unit to monitor the Red field signal outputs. Ensure the connector is a 20 pin connector that mates with the P20 Cable from the output file. Provide a high quality connector that is polarized to insure proper mating with the cable. Ensure Ejector latches are included to facilitate removal and prevent the cable from inadvertently disconnecting. Ensure the unit shall function as a standard 210 Signal Monitor when the cable is disconnected. Use the pin assignments shown in Table 925-1.

Table 925 -1 Red Interface Connector			
Pin	Function	Pin	Function
1	Channel 15 Red	11	Channel 9 Red
2	Channel 16 Red	12	Channel 8 Red
3	Channel 14 Red	13	Channel 7 Red
4	Chassis Ground*	14	Channel 6 Red
5	Channel 13 Red	15	Channel 5 Red
6	Special Function #2	16	Channel 4 Red
7	Channel 12 Red	17	Channel 3 Red
8	Special Function #1	18	Channel 2 Red
9	Channel 10 Red	19	Channel 1 Red
10	Channel 11 Red	20	Red Enable
*A jumper option shall be provided to allow the connection of Pin #4 to be made with Chassis Ground.			

2) Front Panel

Ensure the front panel is constructed of sheet aluminum with a minimum thickness of 0.090 in. (2.286 mm), and finished with an anodized coating. Ensure the model information shall be permanently displayed on the front surface.

a) Indicators

Ensure that all display indicators are mounted on the front panel of the Signal Monitor and are water clear, T-1 package, Super Bright type LEDs. Ensure that all fault LEDs are red except the AC POWER indicator which is green. Provide a separate Red, Yellow, and Green indicator for each channel. Label the indicators and provide the information as follows:

- **AC POWER**
Ensure the AC Power indicator flashes at a rate of 2 Hz when the unit has detected a low voltage condition as described in Subsection 925.2.04.A.15. Ensure the AC POWER indicator flashes at a rate of 4 Hz during the minimum flash interval as described in Subsection 925.2.04.A.15. Ensure that the indicator illuminates when the AC Line voltage level is restored above the brownout level. Ensure the indicator extinguishes when the AC Line voltage is less than 80 Vac.
- **VDC FAILED**
Ensure the VDC FAILED indicator illuminates when a 24VDC fault condition is detected. This indicator remains extinguished if the monitor has not been triggered by a 24VDC fault.
- **WDT ERROR**
Ensure the WDT ERROR indicator illuminates when a controller Watchdog fault is detected. Ensure the WDT Error indicator flashes ON once every 2 seconds if the WD Enable switch on the monitor is placed in the OFF position to disable Watchdog monitoring, or the AC Line voltage is below the Watchdog disable level.
- **CONFLICT**
Ensure that the CONFLICT indicator illuminates when a conflicting signal fault is detected.
- **DIAGNOSTIC**
Ensure the DIAGNOSTIC indicator illuminates when one of the following faults is detected: Internal Watchdog fault, Memory Test fault, or Internal power supply fault. This indicator is intended to inform the service technician of a monitor hardware or firmware failure.

- **RED FAIL**
Ensure the RED FAIL indicator illuminates when an absence of signal is detected on a channel(s). Ensure the RED FAIL indicator flashes ON once every two seconds if the RED ENABLE input is not active, or a Special Function input is active, or the EE input is active
- **DUAL IND.**
Ensure the Dual IND. indicator illuminates when a GY-Dual or GYR-Dual Indication fault is detected on a channel(s).
- **CLEARANCE**
Ensure the Sequence indicator illuminates when the minimum Yellow Clearance time has not been met on a channel(s).
- **PCA**
Ensure the PCA indicator illuminates if the Program Card is absent or not properly seated.
If the unit is in the Diagnostic Display mode, ensure the PCA indicator flashes ON (once, twice, or three times) to indicate the fault event number being displayed. See Subsection 925.2.04.A.15.
- **RP DETECT**
Ensure the RP DETECT indicator illuminates when the unit has detected a Conflict, Red Fail, or Dual Indication fault as a result of recurring pulse field inputs.
- **CHANNEL STATUS**
Ensure that during normal operation the 48 Channel Status indicators display all active signals (Red, Green, and Yellow).
In the fault mode, ensure that the Channel Status indicators display all signals active at the time of the fault for six seconds and then indicate the channels involved in the fault for 2 seconds.

b) Front Panel Control-Reset Button

- Provide a momentary SPST Control switch labeled RESET on the unit front panel to reset the monitor circuitry to a non-failed state. Position the switch on the front panel such that the switch can be operated while gripping the front panel handle. Ensure that a reset command issued from either the front panel button or External Reset input is a one-time reset input to prevent the unit from constant reset due to a switch failure or constant external input, and causes all LED indicators to illuminate for 300 ms.
- The Reset button also provides control of the Diagnostic Display mode. For a complete description of Diagnostic Display operation, see Subsection 925.2.04.A.15.

c) Serial Communications Connector

Use this connector to provide EIA-232 serial communications. Ensure that it is a high quality 9 pin metal shell D subminiature type with female contacts. Refer to Table 925-2 for Pin assignments.

Table 925-2 Serial Communications Connector	
Pin	Function
1	DCD*
2	TX DATA
3	RX DATA
4	DTR (Data Terminal Ready)
5	SIGNAL GROUND
6	DSR
7	DSR*
8	CTS*
9	NC
* Provide Jumper options to allow the connection of Pin #4 to be made with Pin #7, and the connection of Pin #8 to be made with Pin #1.	

3) Electronics

a) RMS Voltage Sampling

Use high speed sampling techniques to determine the true RMS value of the AC field inputs. Sample each AC input at least 32 times per cycle. Ensure that the RMS voltage measurement is insensitive to phase, frequency, and waveform distortion.

b) Internal MPU Watchdog

Use a microprocessor for all timing and control functions. Verify continuing operation of the microprocessor by an independent monitor circuit, that forces the Output Relay to the de-energized "fault" state, enable the Stop-Time output, and illuminate the DIAGNOSTIC indicator if a pulse is not received from the microprocessor within 300 ms.

If the microprocessor should resume operation, ensure the Signal Monitor continues to operate. Ensure that this monitoring circuit is also configurable to latch in the fault state. Ensure the unit requires a power-up cycle to reset the circuit once it is triggered.

c) Sockets

In the interest of reliability, ensure that only the PROM memory device for the microprocessor firmware is socket mounted. Ensure that the PROM memory socket is a precision screw machine type socket with a gold contact finish providing a reliable gas tight seal. Low insertion force sockets or sockets with "wiper" type contacts are not acceptable.

d) Internal Power Supply

Use a built-in, high-efficiency switching power supply to generate all required internal voltages. Ensure that all supply voltages regulated. Failure of the internal power supply to provide proper operating voltages shall force the output Relay to the de-energized "fault" state, enable the Stop-Time output, and illuminate the DIAGNOSTIC indicator. Provide a user replaceable slow blow fuse for the AC Line input. Ensure the unit is operational over the AC Line voltage range of 75 Vac to 135 Vac.

e) EIA-232 Interface

Ensure the EIA-232 port interface electronics is electrically isolated from all monitor electronics except chassis ground.

f) Configuration Parameters

Select user-programmed configuration settings using PCB mounted switches or jumpers. Designs requiring a Personal Computer (PC) to program or verify the configuration parameters are not acceptable. Ensure that user-programmed configuration settings that are transferred to memory are stored in a programmable read-only memory (PROM or EEPROM). Designs using a battery to maintain configuration data are not acceptable.

g) Field Terminal Inputs

Ensure that all 120 Vac field terminal inputs provide an input impedance of 150K 50K ohms and be terminated with a discrete resistor having a power dissipation rating of 0.5 Watts or greater and a voltage rating exceeding 350 volts.

h) Component Specifications

Ensure that all electrical components used in the Signal Monitor are rated by the component manufacturer to operate beyond the full unit operating temperature range of -29°F to 165°F (-34°C to $+74^{\circ}\text{C}$).

i) Printed Circuit Boards

Ensure that all printed circuit boards meet the requirements of the *California Traffic Signal Control Equipment Specifications*, January 1989, plus the following requirements to enhance reliability:

- All plated-through holes and exposed circuit traces are plated with solder.
- Both sides of the printed circuit board are covered with a solder mask material.
- The circuit reference designation for all components and the polarity of all capacitors and diodes are clearly marked adjacent to the component. Ensure that Pin #1 for all integrated circuit packages is designated on both sides of all printed circuit boards.
- All electrical mating surfaces are gold plated.
- All printed circuit board assemblies are coated on both sides with a clear moisture-proof and fungus-proof sealant.
- All components and wire harnesses are mounted to the PCB using plated holes. "Piggy back" connections or jumper wires are not acceptable.

15. Type 2018 Signal Monitors:

a. Introduction

This Specification sets forth the minimum requirements for a rack-mountable, eighteen channel, solid-state 2018 Signal Monitor for Traffic Cabinet Assembly. Ensure that as a minimum, the Signal Monitor complies with all applicable Specifications outlined in Chapter 4 of the *California TEES*, January 1989. Where differences occur, this specification governs. Ensure that the manufacturer of the unit is listed on the current GDOT QPL for signal monitors.

Provide a signal monitor that is capable of monitoring eighteen channels consisting of a Green input, a Yellow input, and a Red input for each channel. Ensure that the unit also includes the enhanced monitoring functions described in 925.2.04.A.15.

b. Monitor Functions

1) Conflict Monitoring

Ensure that the Signal Monitor is able to detect the presence of conflicting green or yellow signal voltages on the AC field terminals between two or more non-compatible channels. A Conflict fault (CONFLICT) shall be a latching fault. Ensure that programming of the permissive matrix is contained in the Datakey.

2) Conflict Recognition Time

Ensure the Signal Monitor triggers when voltages on any conflicting channels are present for more than 500 ms. Ensure that the Signal Monitor does not trigger when voltages on any conflicting channels are present for less than 200 ms. Conflicting signals sensed for more than 200 ms and less than 500 ms may or may not trigger the unit.

3) 24VDC Monitoring

Ensure that the Signal Monitor is able to detect that the cabinet +24 Vdc supply has fallen below 18 Vdc. A 24VDC failure (VDC FAIL) shall be a latching fault.

4) 24VDC Recognition Time

Ensure that the Signal Monitor shall trigger when the voltage on the +24V input is below 18 Vdc for more than 500 ms. Ensure that the Signal Monitor does not trigger when the voltage on the +24V input is below 18 Vdc for less than 200 ms. A voltage level of +22 Vdc will be required to prevent the unit from triggering.

5) Controller Watchdog Monitoring

Ensure that the Signal Monitor triggers when the Watchdog input does not toggle within the programmed time period (WDT ERROR). Ensure that the unit remains latched in the fault state until reset by the Reset button, an External Reset input command, or AC Line voltage restoring from an AC Line Brownout event. Ensure that a reset resulting from an AC Line Brownout event does not clear the WDT ERROR LED.

a) Controller Watchdog Latch Option

Ensure a Datakey programming option sets the Watchdog monitoring function to a latching mode and that only a reset from the Reset button or External Reset input can clear a Watchdog fault. Ensure that an AC Line brownout condition does not reset the fault.

b) Controller Watchdog Recognition Time

Ensure a Datakey programming option sets the maximum Watchdog recognition time to 1000 + or - 100 ms; or 1500 + or - 100 ms.

c) Controller Watchdog Enable Switch

Provide an internal switch to disable the Watchdog monitoring function. Mount the switch on the PCB and be clearly label "WD ENABLE - ON...OFF". Ensure that placement of the switch in the OFF position causes monitoring of the Watchdog to be inhibited.

d) WDT ERROR LED Control

Ensure that the WDT ERROR LED illuminates when the unit has been triggered by a Watchdog fault. Ensure that it can only be cleared by a reset command from the front panel Reset switch or External Reset input. If the Watchdog monitoring function is inhibited due to the Watchdog Enable switch, the WDT ERROR LED shall flash at a 0.5 Hz rate.

6) AC Line Monitoring

a) AC Line Brownout Recognition

Ensure that the Signal Monitor is able to detect that the AC Line has fallen below 98 ± 2 Vac for greater than 400 ± 50 ms. This shall force the output Relay to the de-energized "fault" state, enable the Stop-Time output, and cause the AC POWER LED to flash at a 2 Hz rate. Ensure that the unit maintains this state until the AC Line voltage rises above 103 ± 2 Vac for greater than 400 ± 50 ms. Provide a jumper option which will change the AC Brownout dropout level to 92 ± 2 Vac and the restore level to 98 ± 2 Vac.

b) AC Line Power-up and Brownout Delay Time

When the AC Line is greater than 103 ± 2 volts after power-up or Brownout restore, ensure that the Signal Monitor holds the Output Relay in the de-energized "fault" state and enable the Stop-Time output, for a period of not less than 6.0 ± 0.5 seconds and not greater than 10.0 ± 0.5 seconds. Ensure that this flash interval is terminated after at least 6.0 ± 0.5 seconds if the Signal Monitor has detected at least five transitions of the Watchdog input. If the Signal Monitor does not detect five transitions of the Watchdog input before 10.0 ± 0.5 seconds, ensure that the Signal Monitor goes to the fault state. During this interval, ensure that the AC POWER LED flashes at a 4 Hz rate.

Ensure that the Datakey Minimum Flash Time parameter has a range of zero and from six to sixteen seconds.

7) Red Fail Monitoring

Ensure that the Signal Monitor is able to detect the absence of an active voltage on the green and yellow and red field signal inputs of a channel. Red Fail fault (RED FAIL) shall be a latching fault. Ensure that the Red Fail monitoring function is enabled in the Datakey on a per channel basis except when the Red Enable input is not active, or pin #EE is active, or Special Function #1 input is active, or Special Function #2 input is active.

a) Red Fail Recognition Time

Ensure the Signal Monitor triggers when an active voltage on one of the three inputs of a channel are absent for more than 1500 ms. Ensure that the Signal Monitor does not trigger when an active voltage on one of the three inputs of a channel are absent for less than 1200 ms. Channels without proper voltages sensed for more than 1200 ms and less than 1500 ms may or may not trigger the unit. Ensure that a Datakey Red Fail Timing option is provided which will change the fault recognition time between 700ms and 1000 ms.

b) Red Interface Cable Fault

Ensure a Datakey programming option is provided such that operating without the Red Interface cable installed shall cause the Signal Monitor to enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. To indicate this fault mode, ensure that the Red Fail indicator is illuminated with all fault channel indicators Off.

Ensure that any Red Fail preemption control to the monitor uses the Special Function inputs #1 or #2.

8) Dual Indication Monitoring

Ensure that the Signal Monitor is able to detect the presence of active voltage on the green and yellow, green and red, or yellow and red field signal inputs of a channel. GYR Dual Indication fault (DUAL IND) shall be a latching fault. Ensure this function is enabled in the Datakey on a per channel basis for Green and Yellow combinations, Green and Red combinations, and Yellow and Red combinations. Ensure that the GYR Dual Indication monitoring function is enabled for all selected channels except when the Red Enable input is not active or pin #EE is active.

a) GY Dual Indication Monitoring

Ensure that the Signal Monitor is able to detect the presence of active voltage on the green and yellow field signal inputs of a channel. GY Dual Indication fault (DUAL IND) shall be a latching fault. Enable this function with a dip switch on the PCB labeled "GY ENABLE". When the switch is in the ON position, monitor all channels for simultaneous active green and yellow inputs on a channel. When selected by the GY ENABLE switch, ensure that the GY Dual Indication monitoring function is disabled when pin #EE is active.

b) Dual Indication Recognition Time

Ensure that the Signal Monitor triggers when multiple inputs are active on a channel for more than 500 ms. Ensure that the Signal Monitor does not trigger when multiple inputs are active on a channel for less than 250 ms. Channels with multiple voltages active for more than 250 ms and less than 500 ms may or may not trigger the unit.

9) Clearance (Short or Absent Yellow) Monitoring

Ensure that the Signal Monitor is able to detect that a channel has not provided an adequate Yellow Clearance interval during a green to yellow to red sequence. A Sequence failure (SEQUENCE) shall be a latching fault. Ensure that this function is enabled in the Datakey on a per channel basis. Ensure that the Sequence monitoring function is enabled for all selected channels except when the Red Enable input is not active or pin #EE is active.

10) Clearance Recognition Time

Ensure that the Yellow Clearance interval is 2.7 seconds

11) Flickering Indication Detection

Ensure that the Signal Monitor provides a method of detecting Conflict, Red Fail, and Dual Indication faults that result from intermittent or flickering field signal inputs that may not meet the duration requirements but continue to flicker for an extended period of time. These flickering indications shall result in a latching fault with an indication illuminated along with the resulting Conflict, Red Fail, or Dual Indication indicator. Insure a programming option is provided in the Datakey to disable the RP Detect function.

12) Configuration Change Monitoring

On power-up, reset, and periodically during operation, ensure that the Signal Monitor compares the current configuration settings with the previously stored value and if the settings have changed, the Signal Monitor automatically logs the new setting. Ensure that these settings include the permissive diode matrix, all switches, all jumpers, and the Watchdog Enable switch.

Provide a programming option such that any change in the configuration parameters will cause the Signal Monitor to enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. To indicate this fault mode ensure that the PCA indicator will flash at a 4 Hz rate. Depressing the Reset button for 5 full seconds is required to clear this fault and log the new configuration parameters.

If the programming option is not selected, ensure that the unit does not set the fault mode but will still log the configuration change.

13) Program Card Ajar

Ensure that when the Programming Card is removed or not seated properly, the Signal Monitor forces the Output Relay to the de-energized "fault" state, enable the Stop-Time output, and illuminate the PCA LED. A reset command from the front panel Reset switch or External Reset input is required once the Program Card is in place.

14) Datakey Error

Ensure that when the Datakey is removed or when a nonvalid Datakey is inserted, the Signal Monitor forces the Output Relay to the de-energized fault state, enables the Stop-Time output, and illuminates the KEY indicator. Ensure that a reset command from the front panel Reset switch or External Reset input is required once a valid Datakey is in place. Ensure that failure to read the Datakey correctly results in a Datakey Error illuminating the KEY indicator.

15) Exit Flash

When the Signal Monitor exits the flash state (Output relay de-energized) as a result of a Reset command or AC Line brownout restore, ensure that the Stop Time output goes to the inactive state 250 + OR - 50 ms before the Output relay transfers to the energized state. This transition will provide an early indication to the Controller Unit that the cabinet will transfer from flash to signal operation.

c. Display Functions

1) Ensure that it is possible to view the active channels for each individual color (GYR) during operation and when latched in a fault state. When the Signal Monitor is latched in a fault state ensure that it is also possible to view the active channels for each individual color and fault status for each channel for the current fault and the two previous faults.

2) Previous Fault GYR Display

When the Signal Monitor has been triggered by a fault, the channel status display will alternate between the channels which were involved in the fault (fault status) for 2 seconds, and the field signals active at the time of the fault for 6 seconds. The channels involved in the fault will flash their respective Green, Yellow, and Red indicators simultaneously at a 4 Hz rate for the 2 second interval.

The two previous faults may also be displayed individually. This status is not reset by an AC Line power interruption. To enter this display mode remove the Datakey. The sequence is as follows:

Reset	Event	PCA LED	Fault Status LEDs	Channel Status LEDs
---	#1	Single flash	Current Fault Status (newest)	Current Field status
#1	#2	Double flash	Event #2 Fault Status	Event #2 Field status
#2	#3	Triple flash	Event #3 Fault Status (oldest)	Event #3 Field status
(repeats back to top)				

To exit this display mode, replace the Datakey.

d. Event Logging Functions

Ensure that the Signal Monitor is capable of storing in non-volatile memory a minimum of 100 events. Mark each event with the time and date of the event. These events consist of fault events, AC Line events, reset events, and configuration change events. Provide a graphical means of displaying the signal states of all field inputs for 30 seconds prior to a fault trigger event. Provide the capability to assign an eight-digit identification number to the unit shall be provided. Upload the event logs to a PC using the serial port of the Signal Monitor and software provided by the manufacturer.

Ensure each event log report contains the following information:

- Monitor ID#: an eight digit (0-99999999) ID number assigned to the monitor.
- Time and Date: time and date of occurrence.
- Event Number: identifies the record number in the log. Event #1 is the most recent event.

1) Monitor Status Report (CS)

Ensure the Current Status report contains the following information:

- Fault Type: the fault type description.
- Field Status: the current GYR field status and field RMS voltages if the monitor is not in the fault state, or the latched field status and field RMS voltages and fault channel status at the time of the fault.
- Cabinet Temperature: the current temperature if the monitor is not in the fault state, or the latched temperature at the time of the fault.
- AC Line Voltage: the current AC Line voltage if the monitor is not in the fault state, or the AC Line voltage at the time of the fault.
- Control Input Status: the current state and RMS voltages of the Red Enable input, EE input, and Special Function #1 and #2 inputs if the monitor is not in the fault state, or the status latched at the time of the fault.

2) Previous Fault Log (PF)

Ensure the Previous Fault log contains the following information:

- Fault Type: the fault type description.
- Field Status: the latched field status with RMS voltages, and fault channel status at the time of the fault.
- Cabinet Temperature: the latched temperature at the time of the fault.
- AC Line Voltage: the AC Line voltage at the time of the fault.
- Control Input Status: the latched state of the Red Enable input, EE input, and Special Function #1 and #2 inputs at the time of the fault.

3) AC Line Event Log (AC)

The AC Line log shall contain the following information:

- Event Type: describes the type of AC Line event that occurred.
 - Power-up—AC on, monitor performed a cold start
 - Interrupt—AC Line < Brownout level
 - Restore—AC restored from brown-out or interruption (AC Off), no cold start
- AC Line Voltage: the AC Line voltage at the time of the event.

4) Monitor Reset Log (MR)

Ensure the Monitor Reset log contains the following information:

- a) Event Type: The monitor was reset from a fault by the front panel Reset button or External Reset input.

- b) Time and Date: the time and date of the event.
- 5) Configuration Change Log (CF)

Ensure the Configuration Change log contains the following information:

 - a) Datakey Contents and any additional programming parameters resulting from hardware configuration settings.
 - b) The log shall indicate which items have been changed since the last log entry.
 - c) Time and Date: the time and date of the event.
- 6) Signal Sequence Log

Provide a log that graphically displays all field signal states for up to 30 seconds prior to the current fault trigger event. Ensure that the resolution of the display is at least 50 milliseconds.
- e. Communications Functions
 - 1) Controller Unit Communications

Type A: Ensure that the Signal Monitor is compatible with the protocol of the current GDOT licensed firmware for 2070 controllers and Central System Control. Ensure the 2018 Conflict Monitor supplied is able to communicate via a serial link to the 2010 Controller and then to a Central System using the current licensed GDOT Central System Software for reporting, configuring and logging.

Type B: Ensure that the Signal Monitor is compatible with the protocol of the current GDOT licensed firmware for 2070 controllers and Central System Control. Ensure the 2018 Conflict Monitor supplied is able to communicate via a RJ-45 connector (Ethernet).
 - 2) Personal Computer Communications

Have the manufacturer provide software to access the Signal Monitor status and event logs described in Subsection 925.2.04.A.14.d. Ensure this software operates with current version of Microsoft Windows or Windows XP™
- f. Hardware
 - 1) Monitor Configuration Programming

Ensure a monitor parameter programming is provided in a removeable and interchangeable Datakey nonvolatile memory device mounted on the front panel.

 - a) Monitor Unit Serial Memory Key

Ensure that the monitor has a Datakey™ model KC4210 Keycepticle™ socket or equal mounted on the front panel containing a Datakey™ model LCK4000-RED serial memory key or equal. Ensure that the serial memory key is rated for -40 to +80 °C operation. (Note: Datakey™ and Keycepticle™ are registered trademarks of Datakey Electronics, Inc.)
 - b) Monitor Unit Serial Memory Key Interface

Ensure that the Signal Monitor does not provide the capability to program the serial memory key. It shall be used only as a read only device. Ensure that the 16 bit Frame Check Sequence (FCS) procedure defined in clause 4.6.2 of ISO/IEC 3309 is used to verify the integrity of the read data. Ensure that failure to read the serial memory key correctly results in a latched Diagnostic fault. Ensure that interface circuitry to the Datakey utilizes the LOFO switch on the serial memory key socket to ensure the device is removed and inserted with no power applied to the interface pins (i.e. dead socket).
 - c) Datakey Programming Tool

Ensure the programming tool provides all the electronics necessary to read data from and write data to the Datakey device. Ensure the programmer is configured to Read and Write to the Datakey model LCK4000 which provides 512 bytes of storage. Ensure power for the programming tool is obtained from the personal computer communications port so that no external power supply source is required.
 - d) Datakey Programming Software

Ensure that the manufacturer provides software to operate the Datakey Programming Tool. Ensure that the Datakey programming parameters are stored in a Windows file format according to currently used Signal Monitor identification number and name.
 - e) Parameter Forms

Ensure that a parameter form is provided for each programmable Signal Monitor function. Ensure that Signal Monitor configuration data is entered on a parameter form and then saved to the main data buffer image. When all parameter forms are completed ensure that a Write function transfers the

contents of the data buffer to the nonvolatile memory of the Datakey device. Ensure that reading the contents of a Datakey device sets the parameters of each form for review or modification.

- f) Datakey Parameter Verify
Ensure that a Datakey Parameter Verify function is provided that compares the contents of a Datakey device with parameters in the data buffer. The data buffer parameters may be set by changing parameters on the forms, reading the contents of a Datakey device, or loading a set of parameters from a file.
 - g) Initial Parameter Setup Wizard
Ensure that an Initial Parameter Setup wizard is provided that defines and sets a basic set of parameters for a new Datakey setup. Ensure that the wizard asks a series of questions describing basic intersection setup and develop a template for the following set of parameters:
 1. Red Fail Monitoring
 2. Dual Indication Monitoring
 3. Clearance Monitoring
 4. Yellow Disable
 - h) Parameter Check Wizard
Ensure that a Parameter Check wizard is provided that will apply a set of basic configuration rules to the data buffer and provide a warning that configuration conflicts or inconsistencies may exist.
 - i) Parameter Reports
Ensure that the contents of the data buffer are displayed in a hex format for numerical analysis. A text report shall also be printed that specifies all parameter settings.
- 2) Red Monitoring
- a) Red Field Inputs
Ensure that the Signal Monitor is capable of monitoring sixteen Red field signals. Ensure that a Red input is sensed active when the input voltage exceeds 70 Vrms. Ensure that a Red input is sensed not active when the input voltage is less than 50 Vrms. A Red input may or may not be sensed active when the input voltage is between 50 Vrms and 70 Vrms.
 - b) Red Enable Input
Ensure that the Red Enable input provides an AC input to the unit which enables Red Monitoring, Dual Indication Monitoring, and Sequence monitoring when the input is sensed active.
Ensure that the Red Enable input is sensed active when the input voltage exceeds 70 Vrms. Ensure that the Red Enable input is sensed not active when the input voltage is less than 50 Vrms. The Red Enable input may or may not be sensed active when the input voltage is between 50 Vrms and 70 Vrms.
 - c) Special Function Preemption Inputs
Ensure that the Special Function Preemption inputs #1 and #2 provide an AC input to the unit which disables only Red Fail Monitoring (Lack of Output) when either input is sensed active.
Ensure that a Special Function input is sensed active when the input voltage exceeds 70 Vrms. Ensure that a Special Function input is sensed not active when the input voltage is less than 50 Vrms. A Special Function input may or may not be sensed active when the input voltage is between 50 Vrms and 70 Vrms.
Ensure that a programming option is provided in the Datakey to invert the active status of the Special function #1 input. When the the option is enabled, ensure that the Special Function #1 input is sensed not active when the input voltage exceeds 70 Vrms. Ensure that the Special Function #1 input is sensed active when the input voltage is less than 50 Vrms. The Special Function #1 input may or may not be sensed active when the input voltage is between 50 Vrms and 70 Vrms.
 - d) Red Interface Connector
This connector provides the required inputs for the unit to monitor the Red field signal outputs. Ensure the connector is a 20 pin connector that mates with the P20 Cable from the output file. Provide a high quality connector that is polarized to insure proper mating with the cable. Ensure Ejector latches are included to facilitate removal and prevent the cable from inadvertently disconnecting. Ensure the unit shall function as a standard 210 Signal Monitor when the cable is disconnected. Use the pin assignments shown in Table 925-1.

Table 925 -1 Red Interface Connector			
Pin	Function	Pin	Function
1	Channel 15 Red	11	Channel 9 Red
2	Channel 16 Red	12	Channel 8 Red
3	Channel14 Red	13	Channel 7 Red
4	Chassis Ground*	14	Channel 6 Red
5	Channel 13 Red	15	Channel 5 Red
6	Special Function #2	16	Channel 4 Red
7	Channel 12 Red	17	Channel 3 Red
8	Special Function #1	18	Channel 2 Red
9	Channel 10 Red	19	Channel 1 Red
10	Channel 11 Red	20	Red Enable
*A jumper option shall be provided to allow the connection of Pin #4 to be made with Chassis Ground.			

3) Front Panel

Ensure the front panel is constructed of sheet aluminum with a minimum thickness of 0.090 in. (2.286 mm), and finished with an anodized coating. Ensure the model information shall be permanently displayed on the front surface.

a) Indicators

Ensure that all display indicators are mounted on the front panel of the Signal Monitor and are water clear, T-1 package, Super Bright type LEDs. Ensure that all fault LEDs are red except the AC POWER indicator which is green. Provide a separate Red, Yellow, and Green indicator for each channel. Label the indicators and provide the information as follows:

- AC POWER

Ensure the AC Power indicator flashes at a rate of 2 Hz when the unit has detected a low voltage condition as described in Subsection 925.2.04.A.15. Ensure the AC POWER indicator flashes at a rate of 4 Hz during the minimum flash interval as described in Subsection 925.2.04.A.15. Ensure that the indicator illuminates when the AC Line voltage level is restored above the brownout level. Ensure the indicator extinguishes when the AC Line voltage is less than 80 Vac.

- VDC FAILED

Ensure the VDC FAILED indicator illuminates when a 24VDC fault condition is detected. This indicator remains extinguished if the monitor has not been triggered by a 24VDC fault.

- WDT ERROR

Ensure the WDT ERROR indicator illuminates when a controller Watchdog fault is detected. Ensure the WDT Error indicator flashes ON once every 2 seconds if the WD Enable switch on the monitor is placed in the OFF position to disable Watchdog monitoring, or the AC Line voltage is below the Watchdog disable level.

- CONFLICT

Ensure that the CONFLICT indicator illuminates when a conflicting signal fault is detected.

- DIAGNOSTIC

Ensure the DIAGNOSTIC indicator illuminates when one of the following faults is detected: Internal Watchdog fault, Memory Test fault, or Internal power supply fault. This indicator is intended to inform the service technician of a monitor hardware or firmware failure.

- RED FAIL

Ensure the RED FAIL indicator illuminates when an absence of signal is detected on a channel(s). Ensure the RED FAIL indicator flashes ON once every two seconds if the RED ENABLE input is not active, or a Special Function input is active, or the EE input is active

- **DUAL IND.**
Ensure the Dual IND. indicator illuminates when a GY-Dual or GYR-Dual Indication fault is detected on a channel(s).
- **SEQUENCE**
Ensure the Sequence indicator illuminates when the minimum Yellow Clearance time has not been met on a channel(s).
- **PCA**
Ensure the PCA indicator illuminates if the Program Card is absent or not properly seated.
If the unit is in the Diagnostic Display mode, ensure the PCA indicator flashes ON (once, twice, or three times) to indicate the fault event number being displayed. See Subsection 925.2.04.A.15.
- **RP DETECT**
Ensure the RP DETECT indicator illuminates when the unit has detected a Conflict, Red Fail, or Dual Indication fault as a result of recurring pulse field inputs.
- **CHANNEL STATUS**
Ensure that during normal operation the 48 Channel Status indicators display all active signals (Red, Green, and Yellow).
In the fault mode, ensure that the Channel Status indicators display all signals active at the time of the fault for six seconds and then indicate the channels involved in the fault for 2 seconds.

b) Front Panel Control-Reset Button

- Provide a momentary SPST Control switch labeled RESET on the unit front panel to reset the monitor circuitry to a non-failed state. Position the switch on the front panel such that the switch can be operated while gripping the front panel handle. Ensure that a reset command issued from either the front panel button or External Reset input is a one-time reset input to prevent the unit from constant reset due to a switch failure or constant external input, and causes all LED indicators to illuminate for 300 ms.
- The Reset button also provides control of the Diagnostic Display mode. For a complete description of Diagnostic Display operation, see Subsection 925.2.04.A.15.

c) Serial Communications Connector

Use this connector to provide EIA-232 serial communications. Ensure that it is a high quality 9 pin metal shell D subminiature type with female contacts. Refer to Table 925-2 for Pin assignments.

Table 925-2 Serial Communications Connector	
Pin	Function
1	DCD*
2	TX DATA
3	RX DATA
4	DTR (Data Terminal Ready)
5	SIGNAL GROUND
6	DSR
7	DSR*
8	CTS*
9	NC
* Provide Jumper options to allow the connection of Pin #4 to be made with Pin #7, and the connection of Pin #8 to be made with Pin #1.	

4) Electronics

a) RMS Voltage Sampling

Use high speed sampling techniques to determine the true RMS value of the AC field inputs. Sample each AC input at least 32 times per cycle. Ensure that the RMS voltage measurement is insensitive to phase, frequency, and waveform distortion.

b) Internal MPU Watchdog

Use a microprocessor for all timing and control functions. Verify continuing operation of the microprocessor by an independent monitor circuit, that forces the Output Relay to the de-energized "fault" state, enable the Stop-Time output, and illuminate the DIAGNOSTIC indicator if a pulse is not received from the microprocessor within 300 ms.

If the microprocessor should resume operation, ensure the Signal Monitor continues to operate. Ensure that this monitoring circuit is also configurable to latch in the fault state. Ensure the unit requires a power-up cycle to reset the circuit once it is triggered.

c) Sockets

In the interest of reliability, ensure that only the PROM memory device for the microprocessor firmware is socket mounted. Ensure that the PROM memory socket is a precision screw machine type socket with a gold contact finish providing a reliable gas tight seal. Low insertion force sockets or sockets with "wiper" type contacts are not acceptable.

d) Internal Power Supply

Use a built-in, high-efficiency switching power supply to generate all required internal voltages. Ensure that all supply voltages regulated. Failure of the internal power supply to provide proper operating voltages shall force the output Relay to the de-energized "fault" state, enable the Stop-Time output, and illuminate the DIAGNOSTIC indicator. Provide a user replaceable slow blow fuse for the AC Line input. Ensure the unit is operational over the AC Line voltage range of 75 Vac to 135 Vac.

e) Output Relay

Ensure the Signal Monitor Output Relay provides both normally open and normally closed contacts. Ensure a programming option is provided to select the polarity of the EE input to accommodate the flash drive voltage state drive on pin EE.

f) EIA-232 Interface

Ensure the EIA-232 port interface electronics is electrically isolated from all monitor electronics except chassis ground.

g) Configuration Parameters

Select user-programmed configuration settings using PCB mounted switches or jumpers. Designs requiring a Personal Computer (PC) to program or verify the configuration parameters are not acceptable. Ensure that user-programmed configuration settings that are transferred to memory are stored in a programmable read-only memory (PROM or EEPROM). Designs using a battery to maintain configuration data are not acceptable.

h) Field Terminal Inputs

Ensure that all 120 Vac field terminal inputs provide an input impedance of 150K 50K ohms and be terminated with a discrete resistor having a power dissipation rating of 0.5 Watts or greater and a voltage rating exceeding 350 volts.

i) Component Specifications

Ensure that all electrical components used in the Signal Monitor are rated by the component manufacturer to operate beyond the full unit operating temperature range of -29°F to 165°F (-34°C to $+74^{\circ}\text{C}$).

j) Printed Circuit Boards

Ensure that all printed circuit boards meet the requirements of the *California Traffic Signal Control Equipment Specifications*, January 1989, plus the following requirements to enhance reliability:

- All plated-through holes and exposed circuit traces are plated with solder.
- Both sides of the printed circuit board are covered with a solder mask material.
- The circuit reference designation for all components and the polarity of all capacitors and diodes are clearly marked adjacent to the component. Ensure that Pin #1 for all integrated circuit packages is designated on both sides of all printed circuit boards.
- All electrical mating surfaces are gold plated.
- All printed circuit board assemblies are coated on both sides with a clear moisture-proof and fungus-proof sealant.
- All components and wire harnesses are mounted to the PCB using plated holes. "Piggy back" connections or jumper wires are not acceptable.

16. Model 208 Monitor Unit

Provide Model 208 Monitor Unit in accordance with CALTRANS TEES and the following. Provide monitor that is on the CALTRANS QPL and provides the pin assignment as shown in Table 925-3.

The Model 208 Monitor Unit shall reliably sense and cause a relay output contact (FAILED STATE) when monitoring the following:

- A Watchdog Timer (WDT) Timeout Condition
- Cabinet +24 VDC Power Supply below specified threshold
- a. WDT Circuitry shall be provided to monitor a controller unit output line state routed to the monitor unit at its assigned pin. The WDT Circuitry shall sense any line state change and the time between the last change. No state change for 1.5 ± 0.1 seconds shall cause a FAILED state. The timer shall reset at each state change in a NON FAILED state.
 - 1) Only the Unit Reset or a WDT inactive due to the voltage sense shall reset the WDT from a FAILED state.
 - 2) A FAILED state caused by the WDT shall illuminate a front panel indicator light label "WDT ERROR". The indicator shall remain ON until Unit Reset Issuance.
 - 3) The WDT Circuitry shall sense the incoming VAC Line and when the voltage falls below 98 ± 2 VAC for 50 ± 17 ms shall inhibit the WDT Function. When the WDT Circuitry sensed the incoming VAC Line rise above 103 ± 2 VAC for 50 ± 2 ms the WDT shall become active. A hysteresis between the Voltage Inhibit and the Voltage Active Setting shall be a minimum of 3 Volts.
- b. Power Supply Monitor Requirements
 - 1) The monitor unit shall sense the Cabinet +24 VDC Power Supply Output Voltage.
 - 2) Voltages sensed at +18 VDC or below for a duration of 500 ms or longer shall cause a FAILED state.
 - 3) Voltages sensed at +22 VDC or above shall NOT cause a FAILED state.
 - 4) Voltages sensed below +22 VDC for a duration of 200 ms or less shall NOT cause a FAILED state.
 - 5) All timing and voltages conditions other than those specified above may or may not cause a FAILED state.
 - 6) A FAILED state caused by sensing the power supply shall illuminate a front panel indicator light labeled "VDC FAILED". The indicator shall remain ON until Unit Reset.
 - 7) Only Unit Reset shall reset the power supply sense circuitry from a FAILED state.
- c. FAILED State Output Circuits
 - 1) An electro-mechanical relay shall be provided to switch an output circuit during a FAILED state. The relay coil shall be energized in a NON FAILED State.
 - 2) The relay contacts shall be rated for a minimum of 3 amperes at 120 VAC and 100,000 operations. Contact opening /closing time shall be 30 ms or less.
- d. Monitor Unit Reset
 - 1) A momentary SPST CONTROL switch labeled "RESET" shall be provided on the unit front panel to reset the monitor unit circuitry to a NON FAILED state. The switch shall be so positioned on the front panel that the switch can be operated while gripping the front panel handle.
 - 2) The unit shall be provided with provision to drive an external NE2H light through a 56K Ohm, ½ Watt Series resistor (resident on unit)
 - 3) The PDA Type 3 WDT Reset Input shall not be sensed by the unit
 - 4) The output relay CONTACT FOR FAILED STATE shall be OPEN.

Table 925-3 Pin Assignments For Model 208 Monitor Unit	
PIN	FUNCTION
1/44	DC Ground
2/43	WDT Ext. Reset
5/40	WDT IN
10/35	+24 VDC
15/30	AC-
17/28	Normally Open, Circ. #2
19/26	AC+
20/25	Normally Closed, Circ. #1
21/24	Circ. Common #1 & #2
22/23	WDT Lamp (External)
NOTE: Card connector keyed between pins 2 & 3, and pins 11 & 12.	

17. Model 242 DC Isolator

Provide Model 242 DC Isolators that are in accordance with the latest version of CALTRANS Specifications as referenced earlier in this section. Provide isolators that:

- Allow the 242 isolator input signal polarity to easily be inverted without the use of tools. Acceptable methods are removable jumpers or dip switches. Unacceptable methods are soldering or desoldering a diode or resistor.
- Output is OFF for input voltages greater than 12 volts;
- Output is ON for voltages of less than 8 volts that have a duration of at least 5 to 25 ms (optional 2-7 ms);
- Minimum output pulse width is 100 ms with a valid input (can be disabled);
- Output is optically isolated open collector NPN transistor;
- Capable of sinking 50 ma when on;
- Can register a new input within 25 ms of the old signal going away; and
- Output clamped on power up and down
- Compatible with 2070 controllers and latest version of CALTRANS TEES including errata

18. Model 200 Switchpack

Provide Model 200 Switchpacks that are in accordance with the latest version of CALTRANS Specifications as referenced earlier in this section.

19. Model 204 Flasher Unit

Provide Model 204 Flasher Units that are in accordance with the latest version of CALTRANS Specifications as referenced earlier in this section.

20. Flash Transfer Relay

Provide Flash Transfer Relays that are in accordance with the latest version of CALTRANS Specifications as referenced earlier in this section.

21. Cabinet Model 332

Ensure surge protection conforms to Table 925-5 Required Surge Arrestors for Model 332 Cabinet.

Supply Model 332 (lower input panel) cabinets, with housing Type 1B, and all components as described in these Specifications.

Supply cabinets having two input files which conform to the CALTRANS Specifications and configured to accept two 2070 controllers in the top portion of the cabinet. Ensure the cabinet has two shelves provided for controller(s).

A manual jack shall be installed inside the cabinet. The jack shall intermate with a three circuit 1/4 inch (6.35 mm) diameter phone plug. The tip and ring (middle) circuits of the jack shall-be connected to the logic ground and the

interval advance inputs of controller unit. When the manual hand cord is plugged into the jack and the pushbutton is pressed, logic ground shall be connected to the interval advance input of the controller unit.

A Manual ON- OFF Switch shall be provided on the police panel which grounds the Manual Control Enable (C1 Pin 53) input to the controller whenever the switch is in the ON position and advance input (C1 Pin 80).

A manual pushbutton with cord shall be provided. The cord shall have a minimum length of 6 feet (1.8 m). It shall have a 1/4 inch (6.35 mm) diameter, three circuit plug connected to one end and a manual pushbutton enclosed in a hand held enclosure at the other end. A complete cycle (push-release) of the manual pushbutton shall terminate the controller unit interval which is active except the vehicular yellow and all red clearance intervals. Cycling the pushbutton during the vehicular yellow or all red clearance intervals shall not terminate the timing of those intervals.

Ensure that the cabinet is configured with an Auxiliary Output File. Additionally, the field wiring terminals may be mounted on the rear of the input file.

22. Cabinet Model 336S (Base Mount)

This unit meets the CALTRANS Specification with the addition of approximately 6 additional inches (150 mm) of cabinet height exclusive of the "M" base adapter. Configure the internal component layout so that the additional space is available in the bottom area of the cabinet cage. Ensure that the field wiring input panels and surge protection conform to Table 925-6 Model 336S Default Input File Assignment Detail and Table 925-7 Required Surge Arrestors for Model 336S Cabinet.

Ensure that the C1 connector harness is provided with pins for all 104 inputs and outputs from the controller.

A manual jack shall be installed on the police panel. The jack shall intermate with a three circuit 1/4 inch (6.35 mm) diameter phone plug. The tip and ring (middle) circuits of the jack shall be connected to the logic ground and the interval advance inputs of controller unit. When the manual hand cord is plugged into the jack and the pushbutton is pressed, logic ground shall be connected to the interval advance input of the controller unit.

A Manual ON- Off Switch shall be provided on the police panel which grounds the Manual Control Enable (C1 Pin 53) input to the controller whenever the switch is in the ON position

A manual pushbutton with cord shall be provided. The cord shall have a minimum length of 3 feet (0.9 m). It shall have a 1/4 inch (6.35 mm) diameter, three circuit plug connected to one end and a manual pushbutton enclosed in a hand held enclosure at the other end. A complete cycle (push-release) of the manual pushbutton shall terminate the controller unit interval which is active except the vehicular yellow and all red clearance intervals. Cycling the pushbutton during the vehicular yellow or all red clearance intervals shall not terminate the timing of those intervals.

23. Cabinet Model 336S (Pole Mount)

Ensure that this unit meets the requirements of Subsection 925.2.04.A.22 above, except that the cabinet is configured for pole mounting as specified in the General Requirements for Type 170 Cabinet Assemblies.

24. Cabinet Model 336S (Base Mount with Auxiliary Output File)

Ensure that this unit meets the requirements of Subsection 925.2.04.A.22 above, except that the cabinet is configured with an Auxiliary Output File. Additionally, the field wiring terminals may be mounted on the rear of the input file.

25. Cabinet Model 337

The Model 337 cabinet is a compact cabinet with an output capacity of four vehicle phases plus two pedestrian phases; the dimensions not to exceed 17 inches (425 mm) deep x 20 inches (500 mm) wide x 35 inches (875 mm) high and its shipping weight not to exceed 175 pounds (80 kg).

Supply the cabinet assembly with capacity for 11, two-channel slots in the input file.

Ensure that the pin assignments of the C1 connector are compatible with the 2070 controller as applicable according to the required number of input/outputs.

Ensure that the 337 cabinet uses standard Type 170 input and output file units.

Equip the cabinet with a C2 connector harness with field terminals protected with surge protectors for communication inputs as specified under communications inputs.

Ensure that the cabinet has two full-size doors to allow complete access from the front or back of the cabinet. Design the rack assembly to mount in CALTRANS standard rails to allow for a Model 204 flasher.

Provide a receptacle to accept the plug in power distribution assembly card guides and edge connectors for the input file card guides to support the conflict monitor, and load switches and flash transfer relays.

Due to the compact design of this cabinet assembly, the Department of Transportation may accept a non-standard type of power distribution assembly (PDA).

26. Cabinet Model 334 with Auxiliary Output File for Ramp Metering Operations

The Controller Cabinet shall comply with the CALTRANS Traffic Signal Equipment Specifications (1989), Model 334 Cabinet Specifications (Chapter 6). **DO NOT** use the February 1993 Amendments for Specifications for the Model 334C Cabinet. Do use the Specification Clarifications dated December 20, 1993.

Provide Cabinet configured as shown in Figure 925-1.

Provide Detector Test Switch Panel. Before providing cabinet submit Detector Switch Test panel design and mounting location for approval. Panel shall include one switch for each of the 13 detector inputs.

- a. The Detector Test Switch Panel shall be mounted in the cabinet on the rails. The panel shall be fabricated from brushed aluminum.
- b. Each switch will be labelled as to function. The label shall be silkscreened on the test panel and be at least ¼ inch in height.
- c. A three position switch shall be provided for each detector input. The switch shall function as follows:
 - Down (Momentary) – Call is placed into the controller on the appropriate input in parallel with field input
 - Up (Lock) – Call is placed into the controller on the appropriate input in parallel with field input.
 - Center (Lock) – Normal Operation field output of detector is connected to the controller unit.

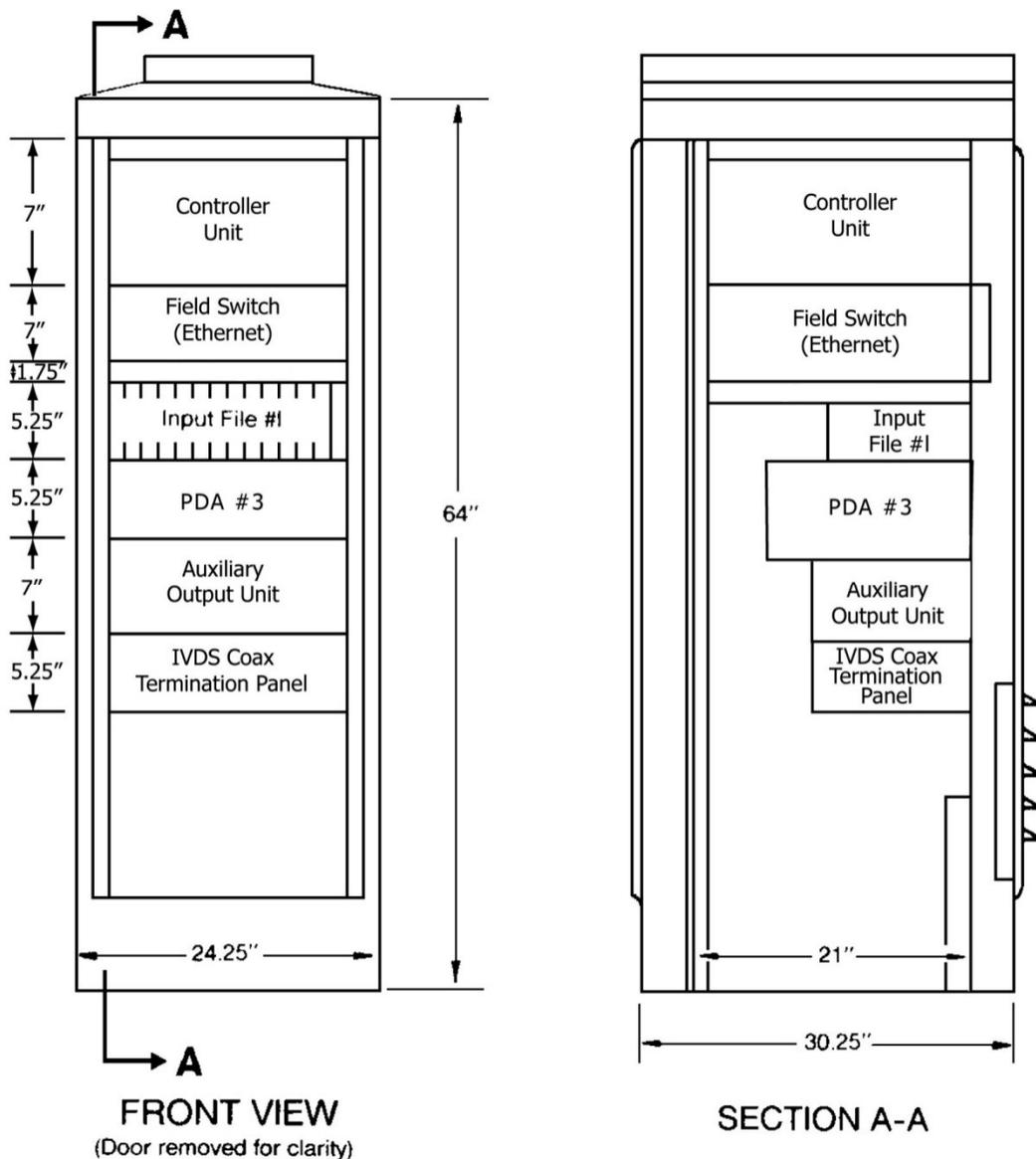


Figure 925-1 Typical 334 Cabinet Configuration

B. Fabrication

1. Cabinet

The signal cabinet shall be manufactured of aluminum with a minimum thickness of 0.125 inches (3 mm).

Ensure that the cabinet exterior has a smooth, uniform “bare” aluminum finish with all joints between adjoining cabinet components (sides and bottom) continuously welded on the outside to prevent the intrusion of moisture and dust.

Ensure that all welds are free of cracks, blow holes and other irregularities.

Ensure that shelves inside the cabinet are vented in order to allow circulation of air throughout the cabinet.

Required shelves include but are not limited to those used for the input file, output file, and PDA.

Use a cabinet door that is double flanged on all four sides to prevent the entry of dirt and liquids when the door is open.

Install a gasket formed around the door opening to insure a weather tight seal when the door is secured.

Attach the door to the cabinet housing by a continuous tamper proof hinge.

Equip each cabinet with a Corbin #2 lock and one key. Police panel type locks are not acceptable.

Install an aluminum back panel in the cabinet, mounted on standoffs, to facilitate mounting of internal components.

Install exterior aluminum mounting brackets, which extend a minimum of 1.75 inches (44 mm) and a maximum of 2.5 inches (63 mm) from the top and bottom of the cabinet.

Use brackets that extend across the full width of the cabinet back on the top and bottom.

Provide these brackets with holes for mounting to a flat surface with screws and vertical slots for banding to steel, concrete or wooden signal poles.

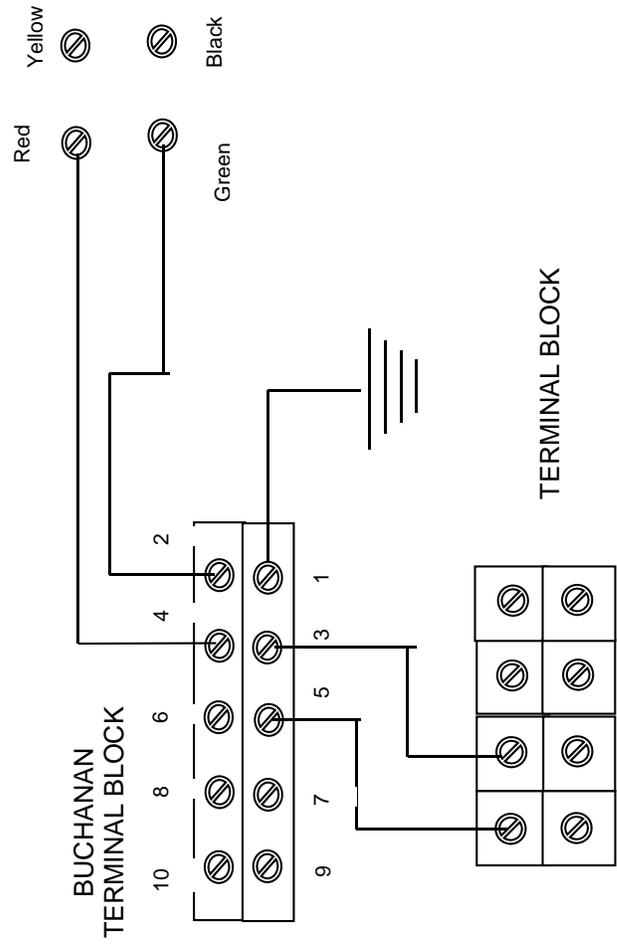
C. Acceptance

Refer to Subsection 925.2.02 for compliance with CALTRANS QPL.

D. Materials Warranty

Refer Subsection 925.2.01.D for Materials Warranties.

Table 925-5 Required Surge Arrestors for Model 332 Cabinet		
Field Terminal Block	Terminals	Required Arrestor
TB-8	1-12	Section 925.2.04.A.13.f
TB-9	10-12	Section 925.2.04.A.13.f
TB-9	4-9	Terminal Block only Section 925.2.04.A.13.f
TB-2, TB-3, TB-4, TB-5, TB-6, TB-7	1-12	Section 925.2.04.A.13.c



Note: For a typical signal installation, the Model 332 cabinet is the design standard.

Figure 925-2—Wiring Diagram for Dial-up Communications

Table 925-6 Model 336S Default Input File Assignment Detail															
Slot		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Type		Det	Det	Det	Det	Det	Det	Det	Det	DC	TBA	TBA	DC	DC	DC
Channel 1	C1 Pin	56	39	58	41	55	40	57	42	51	71	72	67	68	81
	Function	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	Ph7	Ph8	SE1	EVA	EVB	Ph2 PED	Ph6 PED	FLASH
	Field Term	TB-7 1,2	TB-7 5,6	TB-7 9,10	TB-8 1,2	TB-8 5,6	TB-8 9,10	TB-9 1,2	TB-9 5,6	TB-5 1,2	TB-5 5,6	TB-5 9,10	TB-4 1,2	TB-4 5,6	NC
Channel 2	C1 Pin	47	43	49	45	48	44	50	46	52	73	74	69	70	82
	Function	Ph2 CALL	Ph2	Ph4 CALL	Ph4	Ph6 CALL	Ph6	Ph8 CALL	Ph8	R/R	EVC	EVD	Ph4 PED	Ph8 PED	STOP TIME
	Field Term	TB-7 3,4	TB-7 7,8	TB-7 11,12	TB-8 3,4	TB-8 7,8	TB-8 11,12	TB-9 3,4	TB-9 7,8	TB-5 3,4	TB-5 7,8	TB-5 11,12	TB-4 3,4	TB-4 7,8	NC

Table 925-7 Required Surge Arrestors for Model 336S Cabinet		
Field Terminal Block	Terminals	Required Arrestor
TB-4	1-12	Section 925.2.04.A.13.f
TB-5	1-4	Section 925.2.04.A.13.f
TB-5	5-12	Terminal Block only Section 925.2.04.A.13.f
TB-7, TB-8, TB-9	1-12	Section 925.2.04.A.13.c

Table 925-8 Model 334 Default Input File Assignment Detail																
Slot		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Type		Det	Det	Det	Det	Det	Det	Det	Det	Det	Det	Det	TBA	TBA	TBA	
Channel 1	C1 Pin	46	50	49	55	51	57	59	61	81	79	53	41	43	45	
	Function	L1 D1	L2 D2	L1 Q1	L3 Q3	L1 MLA	L2 MLA	L3 MLA	L4 MLA			L3 D3				
	Field Term	TB-2 1,2	TB-2 5,6	TB-2 9,10	TB-3 1,2	TB-3 5,6	TB-3 9,10	TB-4 1,2	TB-4 5,6	TB-4 9,10	TB-4 1,2	TB-5 5,6	TB-5 9,10	TB-5 1,2	TB-6 1,2	TB-6 5,6
Channel 2	C1 Pin	39	47	48	56	52	58	60	62	80	82	54	40	42	44	
	Function	L1 P1	L2 P2	L2 Q2		L1 MLB	L2 MLB	L3 MLB	L4 MLB			L3 P3				
	Field Term	TB-2 3,4	TB-2 7,8	TB-2 11,12	TB-3 3,4	TB-3 7,8	TB-3 11,12	TB-4 3,4	TB-4 7,8	TB-4 11,12	TB-4 3,4	TB-5 7,8	TB-5 11,12	TB-5 3,4	TB-6 3,4	TB-6 7,8

Table 925-9 Required Surge Arrestors for Model 334 Cabinet		
Field Terminal Block	Terminals	Required Arrestor
TB-2, TB-3, TB-4	1-12	Section 925.2.04.A.13.c
TB-5	1-4	Section 925.2.04.A.13.c

Table 925 - 10 Model 334 PDA Type 3 Output File			
	SP 1	SP 2	SP 3

	C1 Pin	Out #	Conn	Func	Field Term	C1 Pin	Out #	Conn	Func	Field Term	C1 Pin	Out #	Conn	Func	Field Term
SP R	2	0	C6-1	Warn 1	T4-7	4	2	C6-3	Lane 1 R	T4-4	7	5	C6-6	Lane 2 R	T4-1
SP Y	37	34	C6-9		T4-8	5	3	C6-4	Lane 1 Y	T4-5	8	6	C6-7	Lane 2 Y	T4-2
SP G	3	1	C6-2	Warn 2	T4-9	6	4	C6-5	Lane 1 G	T4-6	9	7	C6-8	Lane 2 G	T4-3

Table 925 - 11 Model 334 Auxiliary Output File																
	SP 9					SP 10					SP 11					
	C1 Pin	Out #	Conn	Func	Field Term	C1 Pin	Out #	Conn	Func	Field Term	C1 Pin	Out #	Conn	Func	Field Term	
SP R	97	53	C5-14	Lane 3 R	A124	94	50	C5-11	Not used	A121	91	48	C5-9	Not used	A114	
SP Y	98	54	C5-15	Lane 3 Y	A125	95	51	C5-12	Not used	A122	101	37	C5-18	Not used	A115	
SP G	99	55	C5-16	Lane 3 G	A126	96	52	C5-13	Not used	A123	93	49	C5-10	Not used	A116	
	SP 12					SP 13					SP 14					
	C1 Pin	Out #	Conn	Func	Field Term	C1 Pin	Out #	Conn	Func	Field Term	C1 Pin	Out #	Conn	Func	Field Term	
SP R	88	45	C5-6	Not used	A111	85	42	C5-3	Not used	A104	83	40	C5-1	Not used	A101	
SP Y	89	46	C5-7	Not used	A112	86	43	C5-4	Not used	A105	100	36	C5-17	Not used	A102	
SP G	90	47	C5-8	Not used	A113	87	44	C5-5	Not used	A106	84	41	C5-2	Not used	A103	

925.2.05 Type ITS Cabinet Assemblies

A. Requirements

Ensure that the cabinet assembly meets the requirements of the CALTRANS Specifications as described in this document. In addition to the CALTRANS Specifications, ensure that the cabinet assembly conforms to the requirements listed below, which take precedence over conflicting CALTRANS Specifications.

1. Cabinet configuration:

Supply cabinets in accordance with the following information and table 925-12.

- a. Cabinet Traffic Signal Application - Series 340
 - 340 - 4 Door Cabinet with “P” Base Ground Mount
 - 342 - 2 Door Cabinet with “170” Base (332) Ground Mount
 - 346 - 2 Door Cabinet with ”170” Base (336S), Adaptor Mount
- b. Cabinet Traffic Management Application - Series 350
 - 354 - 2 Door Cabinet with “170” Base (332) Ground Mount
 - 356 - 2 Door Cabinet with “170” Base (336S) Adaptor Mount

Table 925-12 ITS Cabinet Configurations					
Items	ITS Cabinet Versions				
	340	342	346	354	356
	Qty	Qty	Qty	Qty	Qty
Housing # 1/ Cage #1		1		1	
Housing # 2/Cage #2			1		1
Housing #3/Two Cage #1	1				
“J” Panel Cage #1	4	2		2	
“J” Panel Cage #2			2		2
Service Panel Assembly with AC -/EG Bus	1	1	1	1	1
Raw/Clean AC power Assembly	1	1	1	1	1
Raw Clean AC power Extension	1				
AC Clean Module Assembly	1				
DC Power/Comm Assembly	2	1	1	1	1
DC Power/Comm Extension	2	1		1	1
Laptop Shelf Assembly	2	1	1	1	1
Input Assembly	3	2	1	1	1
Six Pack Output Assembly	1			1	1
Fourteen Pack output Assembly	1	1	1		
PDA ITS Assembly	1	1	1	1	1
Control/Serial Bus harness	8	6	4	4	4
Serial Bus 3 Harness	3	1	1	1	1

NOTE: Input Assembly shall include a Model 218 SIU. Output Assembly shall include a Model 218 SIU, Model 214 AMU and Model 205 Transfer Relays. The PDA ITS (Traffic Signal Application) shall include two Model 204 Flasher Units, Model 212 CMU and two Model 216 Power Supply Units and attached harnesses. The PDA ITS (Traffic Management System Application) shall include Model 212 CMU and two Model 216 Power Supply Units and attached harnesses.

- c. Model 340 Cabinet:
 - Field termination panels
 - 9 – Flash Transfer Relays
 - 2 – Model 204 Flashers
 - Specific Equipment Layout and other cabinet devices determined on a project specific basis

- d. Model 342 Cabinet:
 - 1-Model 242 DC Isolator
 - 6- Flash Transfer Relays
 - 2-Model 204 Flashers
- e. Model 346 Cabinet
 - 1-Model 242 DC Isolator
 - 6-Flash Transfer Relays
 - 2-Model 204 Flasher
 - 1-"M" Base Adapter installed (Base Mount Cabinets Only)
 - 1-Aluminum Cover Plate for Cabinet Bottom (Pole Mount Cabinets Only)
 - Model 354 Cabinet:
 - Specific Equipment Layout and additional cabinet equipment determined on a project specific basis.
 - Model 356 Cabinet
 - Specific Equipment Layout and additional cabinet equipment determined on a project specific basis.
 - 1-"M" Base Adapter installed (Base Mount Cabinets Only)
 - 1-Aluminum Cover Plate for Cabinet Bottom (Pole Mount Cabinets Only)

Note: Include above components in cabinet at time of delivery.

Other auxiliary cabinet components such as controllers, load switches, etc. will be ordered as separate items.

2. Finish

Use cabinets that have a bare aluminum finish (see Subsection 925.2.04.B.1 for controller-cabinet minimum fabrication specifications).

3. Locks

Equip the main cabinet door with locks that accept No. 2 Corbin keys. Provide two sets of keys with each cabinet. One set of keys is defined as one – No. 2 key and one - police panel key.

4. Power

Equip the cabinet assemblies with an ITS power distribution assembly to generate AC and DC power for the electronic components, except the DC power for the controller units.

5. Mounting

Equip the cabinets for pole or base mounting, as specified in the Plans.

a. Base Mount

Supply Model 346 and 356 cabinets, when specified as base mount, with a “M” base-mounting adapter installed.

b. Pole Mount

Supply Model 346 and 356 cabinets, when specified as pole mount, with two exterior pole mounting brackets that allow for mounting on steel, concrete, and timber poles.

Ensure that the bracket mounting holes are properly reinforced with metal plates of adequate size and strength, welded longitudinally across the inside depth of the cabinet.

Ensure that the exterior-mounting bracket is shipped installed on the cabinet housing. Additionally, provide an aluminum plate, which covers the bottom cabinet opening.

2. Cabinet Light

Include in each cabinet one fluorescent strip lighting fixture mounted inside the top front portion of the cabinet. Do not use a screw in type fluorescent lamp.

The fixture includes a cool white lamp, covered, and operated by a normal power factor, UL listed ballast.

Install a door-actuated switch to turn on the cabinet light when either door is opened.

3. Cabinet Interlock

Do not install the interlock circuit, as detailed in the CALTRANS Specifications.

4. Laptop Shelf

Equip each Model 334, 332, and 336S cabinet with a hinged aluminum shelf and integrated storage compartment mounted on the front door, inside the cabinet assembly. To allow proper ventilation throughout the cabinet, a sliding shelf/drawer shall not be mounted in the rack assembly. The shelf shall have a smooth, non-slip surface, sufficient for use as a writing platform and of sufficient size and stability to support a typical laptop computer when extended. The shelf shall have rounded or insulated edges that do not have the potential to harm the user. The shelf shall lock into place when folded for storage. Locking the shelf for storage and/or extending it for use shall not require the use of any tool.

5. Red Enable Board Cover

The Output File Assembly shall implement a hinged, clear, polycarbonate cover to protect the Red Enable Board during normal operation. This cover shall be hinged on the left or right side. When closed, the side opposite the hinged shall be secured to the Output File Assembly without the use of any hardware or tool. When fully opened, the cover shall not inhibit the removal, replacement or configuration of the Red Enable Board. Removal and replacement of the Red Enable Board shall not require the removal of the protective cover.

6. Test Program

Supply each cabinet with a diagnostic test program, which verifies the operation of the cabinet. Ensure that the program can test cabinet wiring related to the output file, input file, and police panel and flash switches. In addition, ensure that the program can check the operation of the SIU, AMU and CMU by generating all possible conflicts, in sequence.

7. Surge Protection

Equip each cabinet with devices to protect the control equipment from surges and over voltages.

Design the surge protector panels to allow for adequate space for a wire connection and surge protector replacement without the removal of terminal blocks or panels. Provide surge protectors for the input sections as detailed below and as shown in the Input Terminal and Surge Arrestor Detail.

Supply surge protectors that meet the following Specifications.

a. AC Service Input

- Include a surge protection unit for each cabinet on the AC service input that meets or exceeds the following requirements:
 - Provide a hybrid type power line surge protection device on a service panel which plugs into a 12 pin Beau Connector which mounts on a service panel.
- Install the protector between the applied line voltage and earth ground. Use a surge protector capable of reducing the effect of lightning transient voltages applied to the AC line that conforms to the following:
 - Peak surge current for an 8 x 20 μ s waveform:
 - 20,000A for 20 occurrences
 - Clamp voltage @ 20,000A
 - 280V max
 - Maximum continuous operating current:
 - @ 120V / 60 Hz 10A
 - Series Inductance:
 - AC Line/AC Neutral - 200 microhenries
 - Response time:
 - Voltage never exceeds 280V during surge
 - Spike suppression for +/- 700 V spike:
 - +/- 40 V deviation from sine wave at all phases angles between 0 and 180 degrees.
- Provide a protector with the following terminals:
 - Main Line (AC line first stage terminal)
 - Main Neutral (AC neutral input terminal)
 - Equipment Line In (AC line second stage input terminal, 10A)
 - Equipment Line Out (AC line second stage output terminal, 10A)
 - Equipment neutral out (neutral terminal to protected equipment)
 - GND (Earth connection)

- Supply a protector that is epoxy encapsulated in a flame-retardant material.
- Configure the Equipment Line Out to provide power to the Type 2070 and to the 24 V power supply.

b. Inductive Loop Detector Inputs

Protect each inductive loop detector channel input by an external surge protection device that meets or exceeds the following requirements:

- A three-terminal device, two (2) of which are connected across the signal inputs of the detector with the third connected to the chassis ground to protect against common mode damage.
- Instantly clamps differential mode surges (induced voltage across the loop detector input terminals) via a semiconductor array. The array appears as a low capacitance to the detector.
- Clamps common mode surges (induced voltage between the loop leads and ground) via solid state clamping devices.
- Withstand 25-100A surge current occurrences of a 10 x 700 μ s waveform.
- Have the following clamp characteristics:

Maximum break over voltage:	170 V
Maximum on-stage clamping voltage:	3V
Response Time:	<5 ns
Off-stage leakage current:	<10 μ A
Capacitance:	less than 220 pf
- Ensure that the unit also meets the following minimum requirements:

Peak surge current:	6 times
Differential mode:	400 A (8 x 20 ms)
Common mode:	1,000 A (8 x 20 ms)
Estimated occurrences:	500 @ 200 A
Response time:	40 ns
Input capacitance:	35 pF typical
Temperature:	-40° F to +185° F (-40° C to 85° C)
Mounting:	No. 10-32 x 3/8-inch (No. 5 x 10 mm) bolt
Clamp voltage @ 400 A diff. Mode:	30 V max.
Clamp voltage @ 1,000 A comm.. Mode:	30 V max.

c. Signal Load Switches (Switchpacks)

Provide the output of the switchpack in the output file with transient protection via the nine position transient protection device in the output file. Protect switchpacks from surges on the AC output lines.

Ensure that the transient protectors meet or exceed these requirements:

- Steady state sinusoidal voltage (RMS) rating at 50 to 60 Hz of at least 150 V at 77 °F (25 °C)
- Steady state applied DC voltage rating of at least 200 V at 77 °F (25 °C)
- Transient energy rating is of at least 80 J for a single impulse of 10/1,000 μ s current waveform at 77 °F (25 °C)
- Peak current rating of 6,500 A for a single impulse of 8/20 μ s waveform with the rated continuous voltage applied
- Varistor voltage of at least 212 V at 1.0mA of DC current applied for the duration of 20 μ s to 5s
- Clamping voltage of at least 395 V with an applied 8/20 μ s impulse of 100 A
- Typical capacitance at a frequency of 0.1 to 1.0 MHz of 1600 pF
- Two-terminal device, one of which is connected to the AC output of the signal load switch on the output file terminals (backside of the field terminals) with the other connected to AC neutral

d. Communication Inputs

Protect low voltage communications input as it enters the cabinet with a solid-state surge protection unit that meets or exceeds these requirements:

- Dual pair (4-wire) module with a printed circuit board connector, double sided and gold plated for reliability
- Ability to mate with and be installed in a 10-circuit Buchanan connector Part Number PCBIB10S or Tyco Part Number 2-1437410-3 or equivalent
- Usable as two independent signal pairs
- The data circuits pass through the protection in a serial fashion
- C2 connector of the 2070 controller that terminates on the line side of the unit
- Communication field wires for this local side that terminate on the line side of the unit
- Ground terminals connected to power ground
- Ensure that the unit meets the following minimum requirements:

Peak surge current:	10 kA (8 x 20 μ s wave shape) 500A (10 x 700 μ s wave shape)
Occurrences @ peak:	50 typical
Response time:	<1ns
Voltage Clamp:	8V line to line
Series Resistance:	24 Ω total
Temperature	-40 °F (-40 °C) to +185 °F (85 °F)
Primary protector:	3 element gas tube 5kA, (8 x 20 μ s wave shape), per side
Secondary protector:	Silicon avalanche, 1.5 kW minimum

e. Low Voltage DC Inputs

Provide an external surge protection device for each low voltage DC input channel which meets the same requirements as the communication inputs with the following exception of the Voltage clamp, which shall be 30 V line-to-line.

12. Type 212 ITS Cabinet Monitor Unit

a. Introduction

Supply each cabinet with Type 212 ITS Cabinet Monitor Unit (CMU). Ensure the Type 212 CMU meets the CALTRANS TEES Specifications and functions as a unit with the a Type 214 Auxiliary Monitor Unit to provide the following monitoring functions: Cabinet Power Supplies,; Conflicting Channel Monitor, Serial Bus1 and 3 Error; Message 62; Diagnostic Error; Multiple Channel Inputs; Lack of Signal Inputs; Yellow Clearance; Yellow plus Red Clearance; Police and Power Distribution Switch Monitor; door Switches and Main Contactor Status; Circuit Breakers; Flash Unit Output Status; and AC Line Level Sense. Ensure the Unit supplied is listed on the most recent California Department of Transportation Qualified Products List (QPL).

b. Configuration

Supply Type 212 CMU capable of monitoring up to 28 physical load switch channels (RYG) plus 4 virtual channels for a total of 32 channels.

c. Programming

Ensure complete programming of the Type 212 CMU is by an interchangeable Datakey nonvolatile memory device. The Datakey shall store all of the configuration parameters. Ensure the programming of the datakey can easily be accomplished by a PC and provide datakey and programming device with the delivery of the first unit ordered. Orders of multiple ITS cabinets require delivery of 1 programming device with PC software for every 10 cabinets.

d. Logging

Ensure the Type 212 CMU maintains a non-volatile event log recording. The complete intersection status as well as previous fault events, AC Line events, configuration changes, monitor resets, cabinet temperature and true RMS voltages for all field inputs. A real time clock time shall stamp each log event with the time and date.

Ensure a Signal Sequence History Log is stored in nonvolatile memory. The information stored in the signal sequence log shall provide graphic displays of up to 30 seconds of signal status prior to the fault trigger event with 50 ms resolution.

The Type 212 CMU shall be provided with PC Software that allows a review of status, event log review and archival.

13. Type 214 ITS Auxiliary Monitor Unit

a. Introduction

Supply each ITS cabinet output assembly with a Type 214 ITS Auxiliary Monitor Unit (AMU). Ensure the Type 214 CMU meets the CALTRANS TEES Specifications and functions with the a Type 212 Cabinet Monitor Unit to provide cabinet monitoring functions to perform the following monitoring functions: Cabinet Power Supplies, Conflicting Channel Monitor, Serial Bus 1 and 3 Error; Message 62; Diagnostic Error; Multiple Channel Inputs; Lack of Signal Inputs; Yellow Clearance; Yellow plus Red Clearance; Police and Power Distribution Switch Monitor; door Switches and Main Contactor Status; Circuit Breakers; Flash Unit Output Status; and AC Line Level Sense. Ensure the Unit supplied is listed on the most recent California Department of Transportation Qualified Products List (QPL). The Type 214 AMU shall provide the field signal sensing.

b. Current Monitoring

Supply Type 214 AMU capable of operating in a 14 channel mode or a 6 channel mode. Ensure the address select is correct for the output assembly in which the Model 214 AMU is installed.

c. Diagnostics

Ensure the Type 214 AMU has self diagnostic tests that execute continuously to provide for correct operation to properly monitor the current for use with LED signal heads.

14. Type 218 ITS Serial Interface Unit

a. Introduction

Supply each input and output assembly with a Type 218 ITS Serial Interface Unit (SIU). Ensure the Type 218 ITS SIU supplied meets the CALTRANS TEES Specifications. Ensure the Unit supplied is listed on the most recent California Department of Transportation Qualified Products List (QPL). The Type 218 ITS SIU shall provide the interface between the 2070 controller and the input and output files.

b. Configuration

Supply Type 218 SIU capable of operating in all input and output modes. Provide a Model 218 SIU that is configured correctly for the input or output file for which it is supplied.

c. Programming

Ensure programming of the Type 218 SIU is programmed by assembly mounted address jumpers and that no other setup is required.

d. Diagnostics

Ensure the Type 218 SIU supplied has a complete set of internal diagnostics self-tests run continuously to monitor critical components of the unit. Provide unit with a front panel LED indicator that can be used to report the current Input/Output assembly address assignment of the unit for cabinet configuration verification. Ensure unite has a diagnostic EIA-232 port on the front panel to interface with the SIU 218 functions.

15. Model 242 DC Isolator

Provide Model 242 DC Isolators that are in accordance with the latest version of CALTRANS Specifications as referenced earlier in this section. Provide isolators that:

- Allow 242 isolator input signal polarity to easily be inverted without the use of tools. Acceptable methods are removable jumpers or dip switches. Unacceptable methods are soldering or desoldering a diode or resistor.
- Output is OFF for input voltages greater than 12 volts;
- Output is ON for voltages of less than 8 volts that have a duration of at least 5 to 25 ms (optional 2-7 ms);
- Minimum output pulse width is 100 ms with a valid input (can be disabled);
- Output is optically isolated open collector NPN transistor;
- Capable of sinking 50 ma when on;
- Can register a new input within 25 ms of the old signal going away; and
- Output clamped on power up and down

16. Model 200 Switchpack

Provide Model 200 Switchpacks that are in accordance with the latest version of CALTRANS Specifications as referenced earlier in this section.

17. Model 204 Flasher Unit

Provide Model 204 Flasher Units that are in accordance with the latest version of CALTRANS Specifications as referenced earlier in this section.

18. Flash Transfer Relay

Provide Flash Transfer Relays that are in accordance with the latest version of CALTRANS Specifications as referenced earlier in this section.

19. Cabinet Model 342

Provide Cabinet Model 342 that meets the CALTRANS Specification with the addition of surge protection as detailed in Table 925-13 Model 342 ITS Cabinet Default Input Files Assignment Detail, Table 925-14 Required Surge Arrestors for Model 342 ITS Cabinet, and Table 925-15 Model 342 & 346 ITS Cabinet Default Output File Assignment Detail.

Supply Model 342 with lower input panel cabinets, with housing Type 1, and all components as described in these Specifications.

Supply cabinets having two input files which conform to the CALTRANS Specifications and configured to accept two 2070 controllers in the top portion of the cabinet.

Configure the cabinet for dial up communications. Mount a two (2) circuit Buchanan connector on the right side panel (from rear door).

Mount a phone jack with a RJ11 connector above or to the right of the Buchanan terminal block.

Wire the phone jack to the Buchanan and to the Terminal Block (TB0) in accordance with Figure 925-3.

20. Cabinet Model 346 (Base Mount)

This unit meets the CALTRANS Specification with the addition of approximately 6 additional inches (150 mm) of cabinet height exclusive of the "M" base adapter. Configure the internal component layout so that the additional space is available in the bottom area of the cabinet cage. Ensure that the field wiring input panels and surge protection conform to Table 925-16 Model 346 ITS Cabinet Default Input File Assignment Detail, Table 925-17 Required Surge Arrestors for Model 346 Cabinet, and Table 925-15 Model 342 & 346 Default ITS Cabinet Default Output File Assignment.

21. Cabinet Model 346 (Pole Mount)

Ensure that this unit meets the requirements of Subsection 925.2.04.A.19 above, except that the cabinet is configured for pole mounting as specified in the General Requirements for Type ITS Cabinet Assemblies.

22. Cabinet Model 340

The Model 340 cabinet configuration will be determined by the special provisions of the project.

Ensure that the input and output port assignments are compatible with the 2070 controller as applicable according to the required number of input/outputs. Ensure that the 340 cabinet uses standard ITS cabinet input and output file units.

Equip the cabinet with a C2 connector harness with field terminals protected with surge protectors for communication inputs as specified under communications inputs.

Ensure that the cabinet has four full-size doors to allow complete access from the front or back of the cabinet. Design the rack assembly to mount in CALTRANS standard rails to allow for a Model 204 flasher.

Provide a receptacle to accept the plug in power distribution assembly card guides and edge connectors for the input file card guides to support the conflict monitor, and load switches and flash transfer relays.

B. Fabrication

Refer to Subsection 925.2.04.B.1 for controller cabinet minimum fabrication Specifications.

C. Acceptance

Refer to Subsection 925.2.02 for compliance with CALTRANS QPL.

D. Materials Warranty

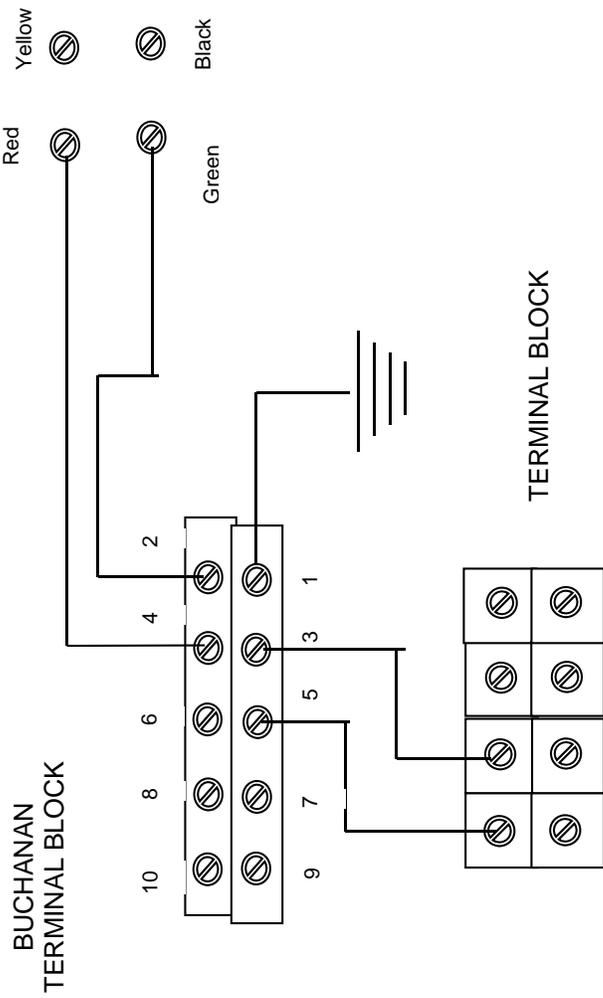
Refer Subsection 925.2.01.D for Materials Warranties.

Table 925 – 13 Model 342 ITS Cabinet Default Input Files Assignment Detail

Input File	Chan	Item	File Slot												
			1	2	3	4	5	6	7	8	9	10	11	12	
1	Upper	SIU Pin	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	
		SIU Byte, Bit	2,6	3,0	3,2	3,4	3,6	4,0	4,2	4,4	4,6	5,0	5,2	5,4	
		SIU Input #	7	9	11	13	15	17	19	21	23	25	27	29	
		2070 Input #	17	0	28	8	22	6	43	25	51	32	12	38	
		2070 Port	3,2	1,1	4,5	2,1	3,7	1,7	6,4	4,2	7,4	5,1	2,5	5,7	
		Function	Ph 1 Det	Ph 2 Det	Ph 2 Det	Ph 2 Det	Ph 3 Det	Ph 4 Det	Ph 4 Det	Sp Det 1	Sp Det 1	Sp Det 5	Pd 2 Det	Pre 1	Pre 5
	Lower	Field Term	TB-2 1,2	TB-2 5,6	TB-2 9,10	TB-4 1,2	TB-4 5,6	TB-4 9,10	TB-6 1,2	TB-6 5,6	TB-6 9,10	TB-8 4,6	TB-9 10,12	TB-9 5,6	
		SIU Pin	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	
		SIU Byte, Bit	2,7	3,1	3,3	3,5	3,7	4,1	4,3	4,5	4,7	5,1	5,3	5,5	
		SIU Input #	8	10	12	14	16	18	20	22	24	26	28	30	
		2070 Input #	21	4	41	19	2	30	10	53	52	34	13	39	
		2070 Port	3,6	1,5	6,2	3,4	1,3	4,7	2,3	7,6	7,5	5,3	2,6	5,8	
2	Opto Inputs	Function	Ph 1 Det	Ph 2 Det	Ph 2 Det	Ph 3 Det	Ph 4 Det	Ph 4 Det	Ph 4 Det	Sp Det 2	Sp Det 6	Pd 4 Det	Pre 2	Pre 6	
		Field Term	TB-2 3,4	TB-2 7,8	TB-2 11,12	TB-4 3,4	TB-4 7,8	TB-4 11,12	TB-6 3,4	TB-6 3,4	TB-6 3,4	TB-6 11,12	TB-8 5,6	TB-9 11,12	TB-9 8,9
		SIU Pin	B25	A26	B26	A27									
		SIU Byte, Bit	8,7	9,0	9,1	9,2									
		SIU Input #	Opto In 1	Opto In 2	Opto In 3	Opto In 4									
		2070 Input #	46	14	47	45									
	Upper	2070 Port	6,7	2,7	6,6	6,8									
		Function	Fish Sen	MCE	Int Adv	S T									
		SIU Pin	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	
		SIU Byte, Bit	2,6	3,0	3,2	3,4	3,6	4,0	4,2	4,4	4,6	5,0	5,2	5,4	
		SIU Input #	7	9	11	13	15	17	19	21	23	25	27	29	
		2070 Input #	16	1	29	9	18	7	44	54	49	33	36	15	
Lower	2070 Port	3,1	1,2	4,6	2,2	3,3	1,8	6,5	7,7	7,2	5,2	5,5	2,8		
	Function	Ph 5 Det	Ph 6 Det	Ph 6 Det	Ph 6 Det	Ph 7 Det	Ph 8 Det	Ph 8 Det	Ph 8 Det	Sp Det 3	Sp Det 7	Pd 6 Det	Spare 1		
	Field Term	TB-3 1,2	TB-3 5,6	TB-3 9,10	TB-5 1,2	TB-5 5,6	TB-5 9,10	TB-7 1,2	TB-7 1,2	TB-7 5,6	TB-7 9,10	TB-8 7,9	TB-8 1,3		
	SIU Pin	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16		
	SIU Byte, Bit	2,7	3,1	3,3	3,5	3,7	4,1	4,3	4,5	4,7	5,1	5,3	5,5		
	SIU Input #	8	10	12	14	16	18	20	22	24	26	28	30		
	2070 Input #	20	5	42	18	3	31	11	55	50	35	37	40		
	2070 Port	3,5	1,6	6,3	3,3	1,4	4,8	2,4	7,8	7,3	5,4	5,6	6,1		
	Function	Ph 5 Det	Ph 6 Det	Ph 6 Det	Ph 7 Det	Ph 8 Det	Ph 8 Det	Ph 8 Det	Ph 8 Det	Sp Det 4	Sp Det 8	Pd 8 Det	Pre 4	Spare 2	
	Field Term	TB-3 3,4	TB-3 7,8	TB-3 11,12	TB-5 3,4	TB-5 7,8	TB-5 11,12	TB-7 3,4	TB-7 3,4	TB-7 7,8	TB-7 11,12	TB-8 8,9	TB-9 7,9	TB-8 2,3	
	Opto Inputs	SIU Pin	B25	A26	B26	A27									
		SIU Byte, Bit	8,7	9,0	9,1	9,2									
SIU Input #		Opto In 1	Opto In 2	Opto In 3	Opto In 4										
2070 Input #		NA	NA	NA	NA										
2070 Port															
Function															

Table 925 – 14 Required Surge Arrestors for Model 342 ITS Cabinet		Required Arrestors for Model 342 Cabinet	
Field Terminal Block	Terminals		
TB - 8	1-12	Section 925.2.05.A.10.f	
TB - 9	10-12	Section 925.2.05.A.10.f	
TB - 9	4-9	Section 925.2.05.A.10.f	
TB - 2, TB - 3, TB - 4, TB - 5, TB - 6, TB - 7	1-12	Section 925.2.05.A.10.c	

Table 925 - 15 Model 342 & 346 ITS Cabinet Default Output File Assignment Detail														
Item	Switch Pack													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SIU Pin	A2	B3	A5	B6	A8	B9	A11	B12	A14	B15	A17	B18	A20	B21
SIU Byte, Bit	2,0	2,3	2,6	3,1	3,4	3,7	4,2	4,5	5,0	5,3	5,6	6,1	6,4	6,7
SIU Output #	1	4	7	10	13	16	19	22	25	28	31	34	37	40
2070 Output #	13	10	8	5	2	0	29	26	24	21	18	16	53	50
2070 Output Port	2,6	2,3	2,1	1,6	1,3	1,1	4,6	4,3	4,1	3,6	3,3	3,1	7,6	7,3
AMU Pin	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29
AMU Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Field Term	TR-1 1,2	TR-2 1,2	TR-3 1,2	TR-4 1,2	TR-5 1,2	TR-6 1,2	TR-7 1,2	TR-8 1,2	TR-9 1,2	TR-10 1,2	TR-11 1,2	TR-12 1,2	TR-13 1,2	TR-14 1,2
Function	Ph 1 Rd	Ph 2 Rd	Pd 2 DW	Ph 3 Rd	Ph 4 Rd	Pd 4 DW	Ph 5 Rd	Ph 6 Rd	Pd 6 DW	Ph 7 Rd	Ph 8 Rd	Pd 8 DW	Ov A Rd	Ov B Rd
SIU Pin	B2	A4	B5	A7	B8	A10	B11	A13	B14	A16	B17	A19	B20	A22
SIU Byte, Bit	2,1	2,4	2,7	3,2	3,5	4,0	4,3	4,6	5,1	5,4	5,7	6,2	6,5	7,0
SIU Output #	2	5	8	11	14	17	20	23	26	29	32	35	38	41
2070 Output #	14	11	32	6	3	34	30	27	33	22	19	35	54	51
2070 Output Port	2,7	2,4	5,1	1,7	1,4	5,3	4,7	4,4	5,2	3,7	3,4	5,4	7,7	7,4
AMU Pin	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29
AMU Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Field Term	TR-1 3,4	TR-2 3,4	TR-3 3,4	TR-4 3,4	TR-5 3,4	TR-6 3,4	TR-7 3,4	TR-8 3,4	TR-9 3,4	TR-10 3,4	TR-11 3,4	TR-12 3,4	TR-13 3,4	TR-14 3,4
Function	Ph 1 Yel	Ph 2 Yel	Pd 2 PC	Ph 3 Yel	Ph 4 Yel	Pd 4 PC	Ph 5 Yel	Ph 6 Yel	Pd 6 PC	Ph 7 Yel	Ph 8 Yel	Pd 8 PC	Ov A Yel	Ov B Yel
SIU Pin	A3	B4	A6	B7	A9	B10	A12	B13	A15	B16	A18	B19	A21	B22
SIU Byte, Bit	2,2	2,5	3,0	3,3	3,6	4,1	4,4	4,7	5,2	5,5	6,0	6,3	6,6	7,1
SIU Output #	3	6	9	12	15	18	21	24	27	30	33	36	39	42
2070 Output #	15	12	9	7	4	1	31	28	25	23	20	17	55	52
2070 Output Port	2,8	2,5	2,2	1,8	1,5	1,2	4,8	4,5	4,2	3,8	3,5	3,2	7,8	7,5
AMU Pin	A16	A17	A18	A19	A20	C21	C22	C23	A24	A25	A26	A27	A28	A29
AMU Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Field Term	TR-1 5,6	TR-2 5,6	TR-3 5,6	TR-4 5,6	TR-5 5,6	TR-6 5,6	TR-7 5,6	TR-8 5,6	TR-9 5,6	TR-10 5,6	TR-11 5,6	TR-12 5,6	TR-13 5,6	TR-14 5,6
Function	Ph 1 Grn	Ph 2 Grn	Pd 2 W	Ph 3 Grn	Ph 4 Grn	Pd 4 W	Ph 5 Grn	Ph 6 Grn	Pd 6 W	Ph 7 Grn	Ph 8 Grn	Pd 8 W	O A Grn	O B Grn



Note: For a typical signal installation, the Model 342 cabinet is the design standard.

Figure 925-3—Wiring Diagram for Dial-up Communications

Table 925 - 16 Model 346 ITS Cabinet Default Input Files Assignment Detail

Input File	Channel	File Slot												
		1	2	3	4	5	6	7	8	9	10	11	12	
1	Upper	SIU Pin	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
		SIU Port	2.6	3.0	3.2	3.4	3.6	4.0	4.2	4.4	4.6	5.0	5.2	5.4
		SIU In #	7	9	11	13	15	17	19	21	23	25	27	29
		2070 In #	17	0	19	2	16	1	18	3	12	36	32	33
		2070 Port	3.2	1.1	3.4	1.3	3.1	1.2	3.3	1.4	2.5	5.5	5.1	5.2
		Function	Ph 1 Det	Ph 2 Det	Ph 3 Det	Ph 4 Det	Ph 5 Det	Ph 6 Det	Ph 7 Det	Ph 8 Det	Ph 8 Det	Pre 1	Pre 3	Pd 2 Det
	Lower	Fld	T-7 1,2	T-7 5.6	T-7 9,10	T-8 1,2	T-8 5.6	T-8 9,10	T-9 1,2	T-9 5.6	T-5 1,2	T-5 5.6	T-4 1,2	T-4 5.6
		SIU Pin	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19
		SIU Port	2.7	3.1	3.3	3.5	3.7	4.1	4.3	4.5	4.7	5.1	5.3	5.5
		SIU In #	8	10	12	14	16	18	20	22	24	26	28	30
		2070 In #	8	4	10	6	9	5	11	7	13	37	34	35
		2070 Port	2.1	1.5	2.3	1.7	2.2	1.6	2.4	1.8	2.6	5.6	5.3	5.4
Opto	Function	Ph 2 Det	Ph 2 Det	Ph 4 Det	Ph 4 Det	Ph 5 Det	Ph 6 Det	Ph 7 Det	Ph 8 Det	Ph 8 Det	Pre 2	Pre 4	Pd 4 Det	Pd 8 Det
	Fld	T-7 3,4	T-7 7,8	T-7 11,12	T-8 3,4	T-8 7,8	T-8	T-9 3,4	T-9 7,8	T-5 3,4	T-5 7,8	T-4 3,4	T-4 7,8	
	SIU Pin	B25	A26	B26	A27									
	SIU Port	8,7	9,0	9,1	9,2									
	SIU In #	Opto In 1	Opto In 2	Opto In 3	Opto In 4									
	2070 In #	46	14	47	45									
	2070 Port	6.7	2.7	6.6	6.8									
	Function	Fish Sen	MCE	Int Adv	S T									

Table 925-17 Required Surge Arrestors for Model 346 ITS Cabinet		
Field Terminal Block	Terminals	Required Arrestor
TB-4	1-12	Section 925.2.05.A.10.f
TB-5	1-4	Section 925.2.05.A.10.f
TB-5	5-12	Terminal Block Only Section 925.2.04.A.10.f
TB-7, TB-8, TB-9	1-12	Section 925.2.05.A.10.c

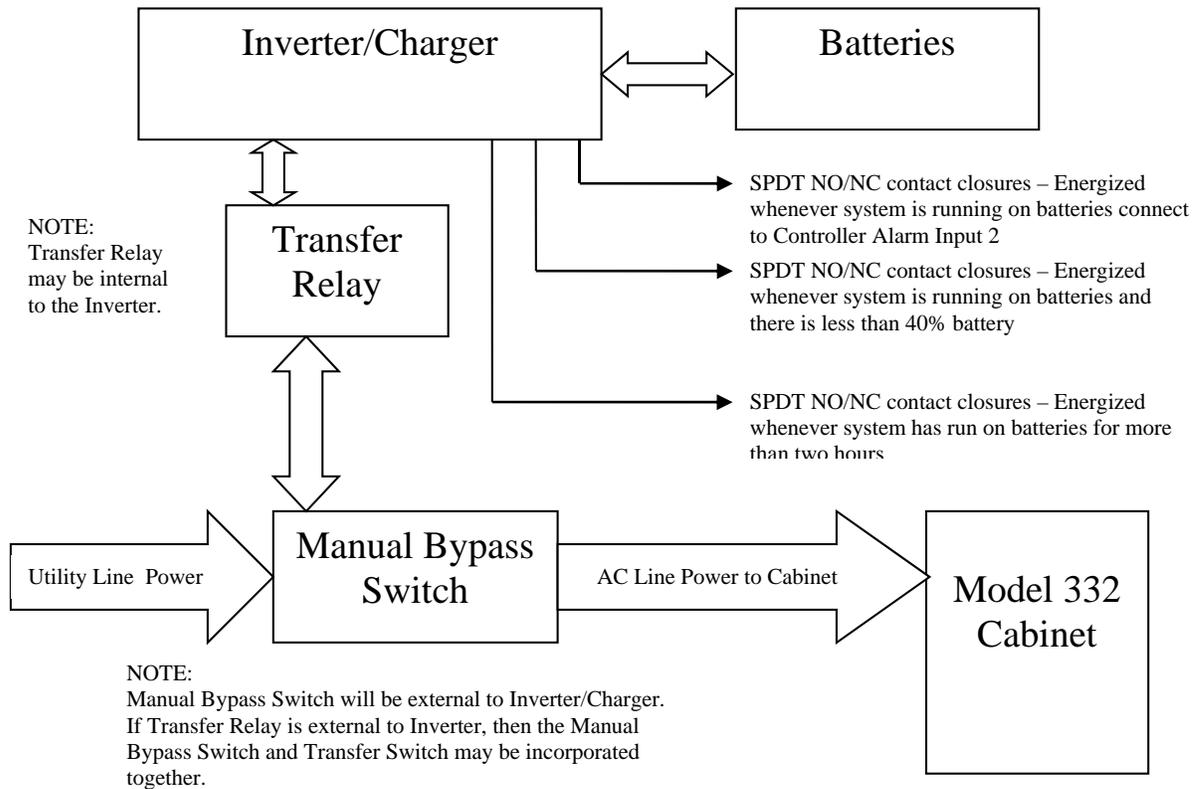
925.2.06 Battery Backup System

A. Requirements

This specification is for establishing the minimum requirements for a complete emergency battery backup system for use with Light Emitting Diode Traffic Signal Modules at intersections with 332 cabinets. The Battery Backup System (BBS) shall include, but not be limited to the following: Inverter/Charger, Power Transfer Relay, Batteries, a separate manually operated non-electric Bypass Switch and all necessary hardware and interconnect wiring. The BBS shall be capable of providing power for full run-time operation for an “LED –only” intersection (all colors: red, yellow, green and pedestrian heads) or flashing mode operation and intersection Red LED’s. The BBS shall be designed for outdoor applications, in accordance with the CALTRANS TEES.

Figure 925-4 Battery Backup Block Diagram

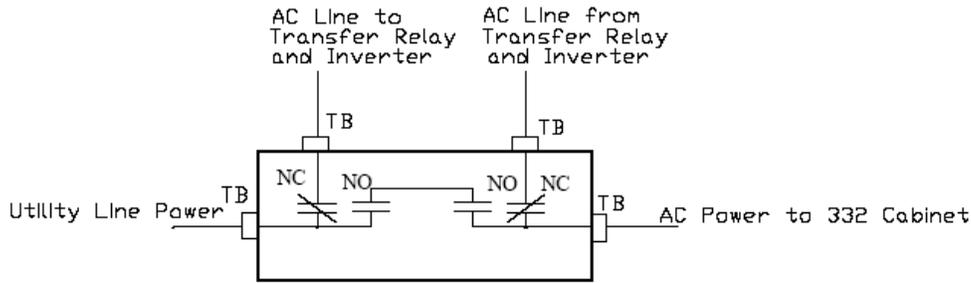
Battery Back Up System (BBS) Block Diagram



2. Operation:

- a. The BBS shall provide a minimum two (2) hours of full run-time operation for an “LED-only” intersection (minimum 700W/1000VA active output capacity, with 80% minimum inverter efficiency).
- b. The maximum transfer time allowed, from disruption of normal utility line voltage to stabilized inverter line voltage from batteries, shall be 65 milliseconds. The same maximum allowable transfer time shall also apply when switching from inverter line voltage to utility line voltage.
- c. The BBS shall include a Manual Bypass Switch which provides capability to transfer the power service to disable the BBS and operate only from the power service provided. The Manual Bypass Switch shall be as shown in Figure 925-5.

Figure 925 – 5 Manual Bypass Switch (Shown in normal BBS Mode)

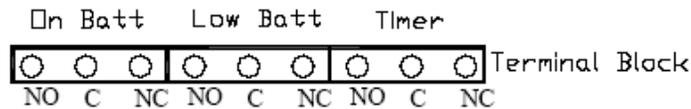


Notes:

1. TB - #8 Terminal Blocks
2. NO - Normally Open
3. NC - Normally Closed
4. NO/NC contacts shall all toggle simultaneously with one single manually operated switch.
5. Manual Bypass Switch shall only switch line. Neutral and Equipment Ground are not switched and shall be connected to 332 Cabinet buses.

- d. The BBS shall provide the user with 3-sets of normally open (NO) and normally closed (NC) single-pole double-throw (SPDT) dry relay contact closures, available on a panel-mounted terminal block, rated at a minimum 120V/1A, and labeled so as to identify each contact. For typical configuration, see Figure 925-6.
- 1) The first set of NO and NC contact closures shall be energized whenever the unit switches to battery power. Contact shall be labeled or marked "On Batt."
 - 2) The second set of NO and NC contact closures shall be energized whenever the battery approaches approximately 40% of remaining useful capacity. Contact shall be labeled or marked "Low Batt."
 - 3) The third set of NO and NC contact closures shall be energized two hours after the unit switches to battery power. Contact shall be labeled or marked "Timer."
 - 4) Relay contact activation shall be annunciated on the front panel via a visual indication. This can be either discreet LED, or part of LCD screen, etc.

Figure 925 – 6 Relay Contacts (NO/NC) available on panel-mounted terminal block (typ)



Notes:

1. NO/NC contacts may either share or use separate commons.

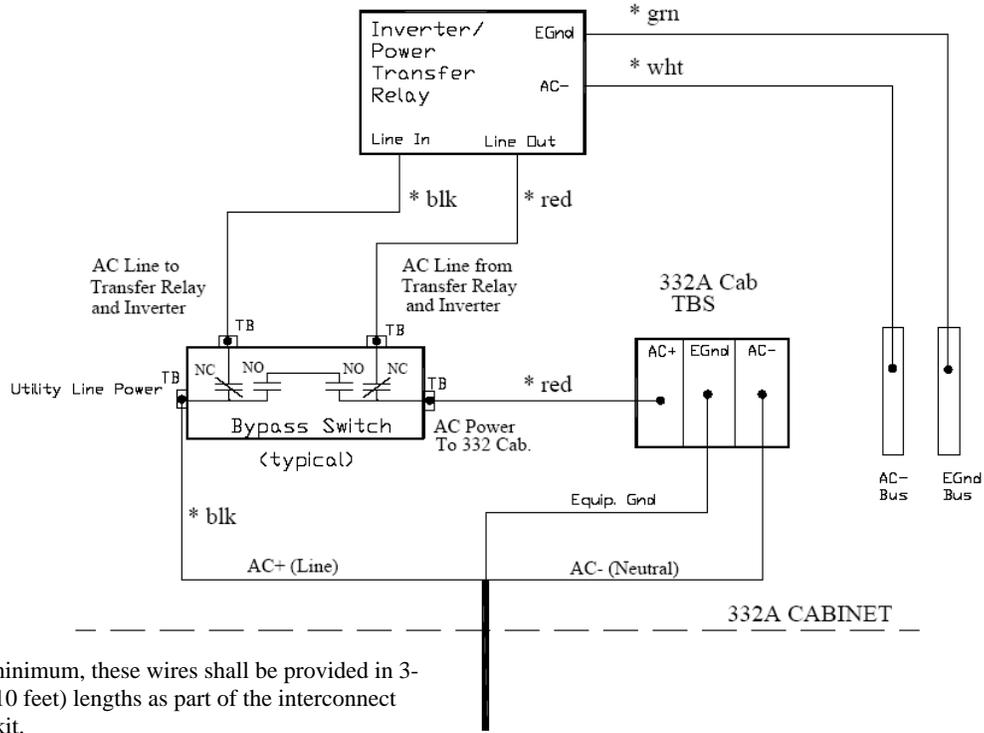
- e. Operating temperature for both the inverter/charger, power transfer relay and manual bypass switch shall be -37°C (-35F) to $+74^{\circ}\text{C}$ ($+165\text{F}$).
- f. Both the Power Transfer Relay and Manual Bypass Switch shall be rated at 240VAC/30 amps, minimum
- g. The BBS shall use a temperature-compensated battery charging system. The charging system shall compensate over a range of 2.5 – 4.0 mV/ $^{\circ}\text{C}$ (5-8 F) per cell. The temperature sensor shall be external to the inverter/charger unit. The temperature sensor shall come with 3 meters (10 feet) of wire. Ensure temperature sensor can be mounted to battery with ring terminal to prevent losing connectivity.
- h. Batteries shall not be recharged when battery temperature exceeds 50°C (122F) $\pm 3^{\circ}\text{C}$ (6 F).
- i. BBS shall bypass the utility line power whenever the utility line voltage is outside of the following voltage range: 100VAC to 130VAC ($\pm 2\text{VAC}$).

- j. When utilizing battery power, the BBS output voltage shall be between 110 VAC and 125 VAC, pure sine wave output, $\leq 3\%$ THD, $60\text{Hz} \pm 3\text{Hz}$.
 - k. BBS shall be compatible with CALTRANS Model 332 Cabinets, Model 170E Controllers, Model 2070 Controllers and cabinet components for full time operation.
 - l. In cases of low (below 98VAC) or absent utility line power, when the utility line power has been restored at above $105\text{ VAC} \pm 2\text{ VAC}$ for more than 30 seconds, the BBS shall transfer from battery backed inverter mode back to utility line mode.
 - m. In cases of high utility line power (above 132VAC), when the utility line power has been restored at below $125\text{VAC} \pm 2\text{ VAC}$ for more than 30 seconds, the BBS shall transfer from battery backed inverter mode back to utility line mode
 - n. BBS shall be equipped to prevent a malfunction feedback to the cabinet or from feeding back to the utility service.
 - o. In the event of inverter/charger failure, battery failure or complete battery discharge, the power transfer relay shall revert to the NC (and de-energized) state, where utility line power is connected to the cabinet.
 - p. Recharge time for the battery, from “protective low-cutoff” to 80% or more of full battery charge capacity, shall not exceed twenty (20) hours.
2. Mounting/Configuration

NOTE: All references made to EIA rail or EIA 19” (482.6mm) rack shall conform to Electronic Industries Standards EIA-310-B, Racks, Panels, and Associated Equipment, with 10-32 “Universal Spacing” threaded holes.

- a. General
 - 1) Inverter/Charger Unit shall be shelf-mounted or rack-mounted on a standard EIA 19” rack. If the inverter/charger is mounted inside the 332 Cabinet (Configuration 1), a shelf shall be provided that supports the weight of the unit.
 - 2) Power Transfer Relay and Manual Bypass Switch shall be mounted on EIA rail.
 - 3) All interconnect wiring shall be provided between Power Transfer Relay, Bypass Switch and Cabinet Terminal Service Block and shall be no less than 3 meters (9’10”) of UL Style 1015 CSA TEW with the following characteristics:
 - AWG Rating: 6 AWG
 - Stranding: 133 strands of 30 AWG tinned copper
 - Rating: 600 V, 105 °C, PVC Insulation
 - 4) Relay contact wiring provided for each set of NO/NC relay contact closure terminals shall be a minimum of 3 meters (10 feet) of UL Style 1015 CSA TEW 18 AWG wire, same ratings as above, except 16 strands of 30 AWG tinned copper. Wiring shall be of adequate length for particular installation.
 - 5) Figure 925-7 provides clarification as to how BBS Power Transfer Relay and Manual Bypass Switch are interconnected with Model 332 Cabinets in order to ensure interchangeability between all BBS manufacturers.

Figure 925- 7 BBS Utility Power Connection Diagram

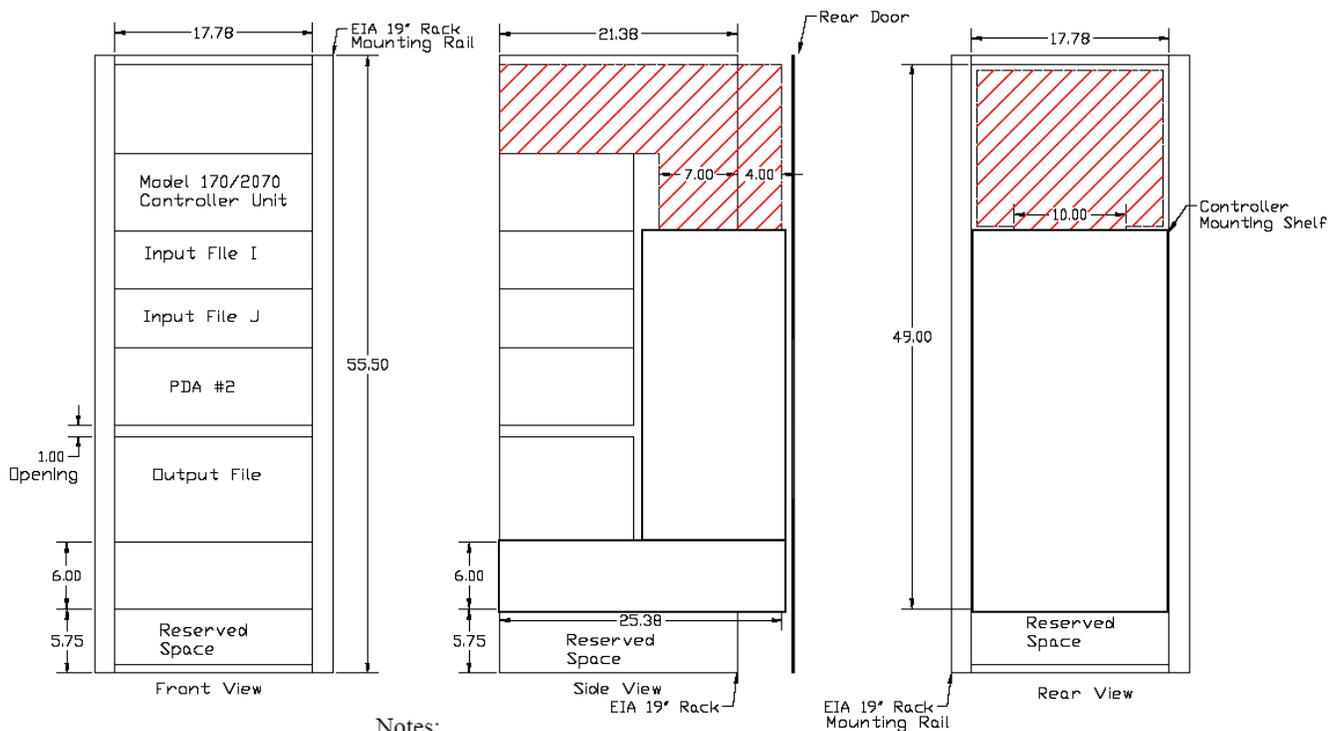


*As a minimum, these wires shall be provided in 3-meter (10 feet) lengths as part of the interconnect wiring kit.

- 6) All necessary hardware for mounting (shelf angles, rack, etc) shall be included in the bid price of the BBS. All bolts/fasteners and washers shall meet the following requirements:
- Screw type: Pan Head Phillips machine screw
 - Size and Thread pitch: 10-32
 - Material: 18-8 stainless steel (Type 316 stainless steel is acceptable as an alternate)
 - Washer: Use one flat washer (18-8 stainless steel) under the head of each 10-32 screw (provided that the screws are properly tightened, lock washers are unnecessary.)
 - Number of screws per hinge bracket: Minimum of six (6) screws per hinge bracket spaced evenly along bracket, with one screw near each end.
- 7) There shall be two (2) basic BBS mounting options:
- a) Configuration 1 – The BBS (Inverter/Charger, Bypass Switch and Transfer Relay only) installed inside the 332 Cabinet, with the batteries installed in the externally mounted cabinet. See Figure 925-8 for location of inverter in 332 cabinet.
 - b) Configuration 2 – The entire BBS, including batteries, installed inside the externally mounted cabinet.

Figure 925-8 BBS Mounting Diagram

For a typical Model 332A Cabinet



Notes:
 Area inside of dashed lines represents available mounting locations for BBS.
 Prescribed available mounting areas are approximate.
 All dimensions shown are in inches.

- 8) External Cabinet
- a) The External Cabinet shall be used for housing batteries and/or BBS, which includes inverter/charger unit, power transfer relay, manually operated bypass switch, any other control panels, and all wiring and harnesses.
 - b) The same Inverter/Charger, Power Transfer Relay and manually operated Bypass Switch that fits inside a typical fully equipped CALTRANS Model 332 Cabinet shall also be able to fit inside the externally mounted cabinet.

- c) The External Cabinet shall be a NEMA 3R rated cabinet conforming to TEES, August 16, 2002 Chapter 7, Section 2-Housings for the construction and finish of the cabinet. The specific finish of the external cabinet shall match the finish of the 332 cabinet. Anti-Graffiti paint shall not be used. Two separate mounting installations shall be used. Refer to the project plans for the appropriate mounting installation.
- Mounting Installation Type A shall be typically used for installing at locations with existing 332 cabinet. This cabinet mounting installation shall attach the external cabinet to the side of the 332 cabinet in the relationship as shown in figure 925-9. Type A mounting installation shall use fasteners that meet the following requirements:
 - (Total of 8 bolts per cabinet with 2 flat washers per bolt and 1 K-lock nut per bolt)
 - Cabinet mounting bolts shall be:
 - 18-8 Stainless Steel Hex Head (Fully Threaded)
 - 3/8" – 16 X 1"
 - Washers shall be:
 - Designed for 3/8" bolt
 - 18-8 Stainless Steel 1" OD round flat type
 - K-lock washer shall be:
 - 18-8 Stainless Steel, Hex Nut Assembled with Free-Spinning Tooth Washer
 - 3/8" – 16 Screw size

External Cabinet to 332 Cabinet couplings shall provide a conduit for power connections between the 332 Cabinet and External Cabinet. The couplings shall consist of three parts and meet the following requirements:

- 2" Nylon Insulated, Steel Chase Nipple
- 2" Sealing, Steel Locknut
- 2" Nylon Insulated, Steel Bushing

The external cabinet shall come provided with all bolts, washers, nuts and cabinet-cabinet coupler fittings provided, necessary for mounting the external cabinet to the 332 Cabinet.

- Mounting Installation Type B shall be typically used for locations where a new traffic controller cabinet and foundation are being installed. This cabinet installation shall provide the external battery cabinet as a base mount cabinet on the same foundation as the 332 cabinet. Connections between the cabinets shall be through conduit in the cabinet base. The external cabinet shall be installed in the same relationship as shown in Figure 925-9 to the 332 cabinet. The external cabinet shall be installed so that it is centered on the 30 inch left side of the 332 cabinet. Bolt BBS cabinet to pre-fab base. BBS cabinet opening shall be larger than the pre-fab base opening.
- d) The specific dimensions and details of the external battery cabinet shall be as shown in Figures 925-10 through 925-12.

Figure 925-9 External BBS Cabinet Details

External Battery Cabinet

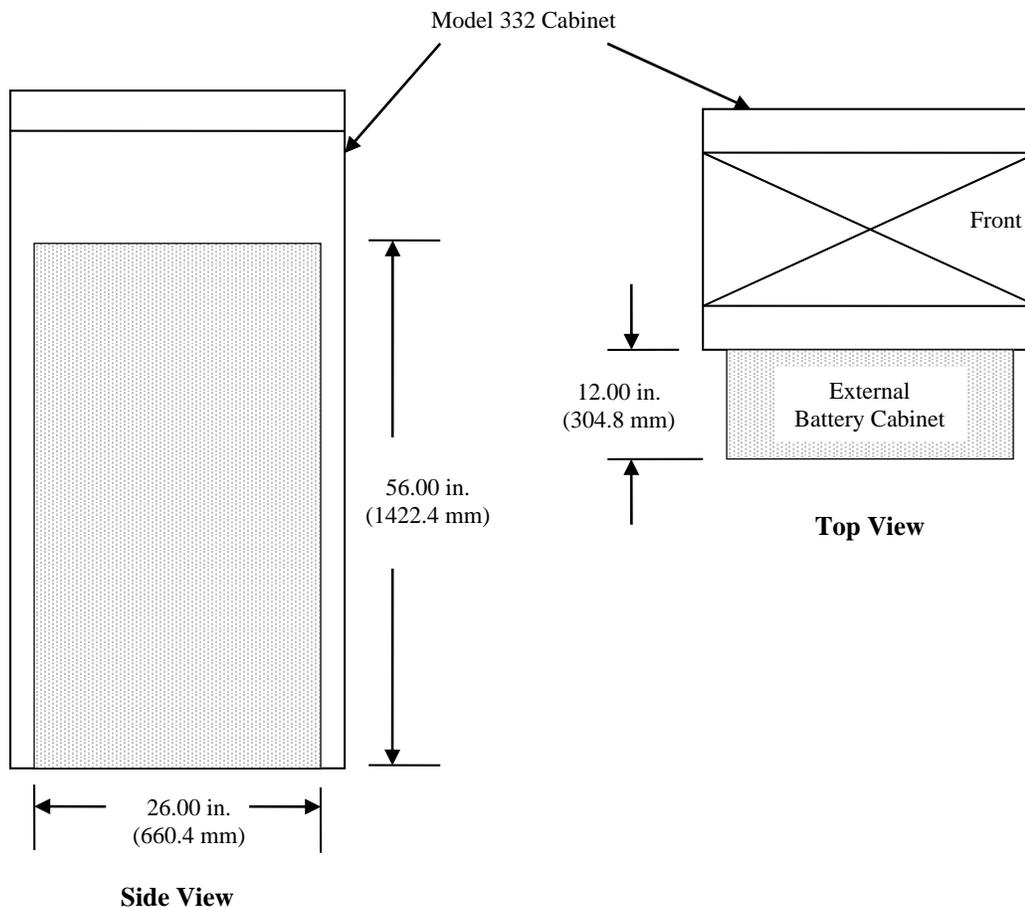
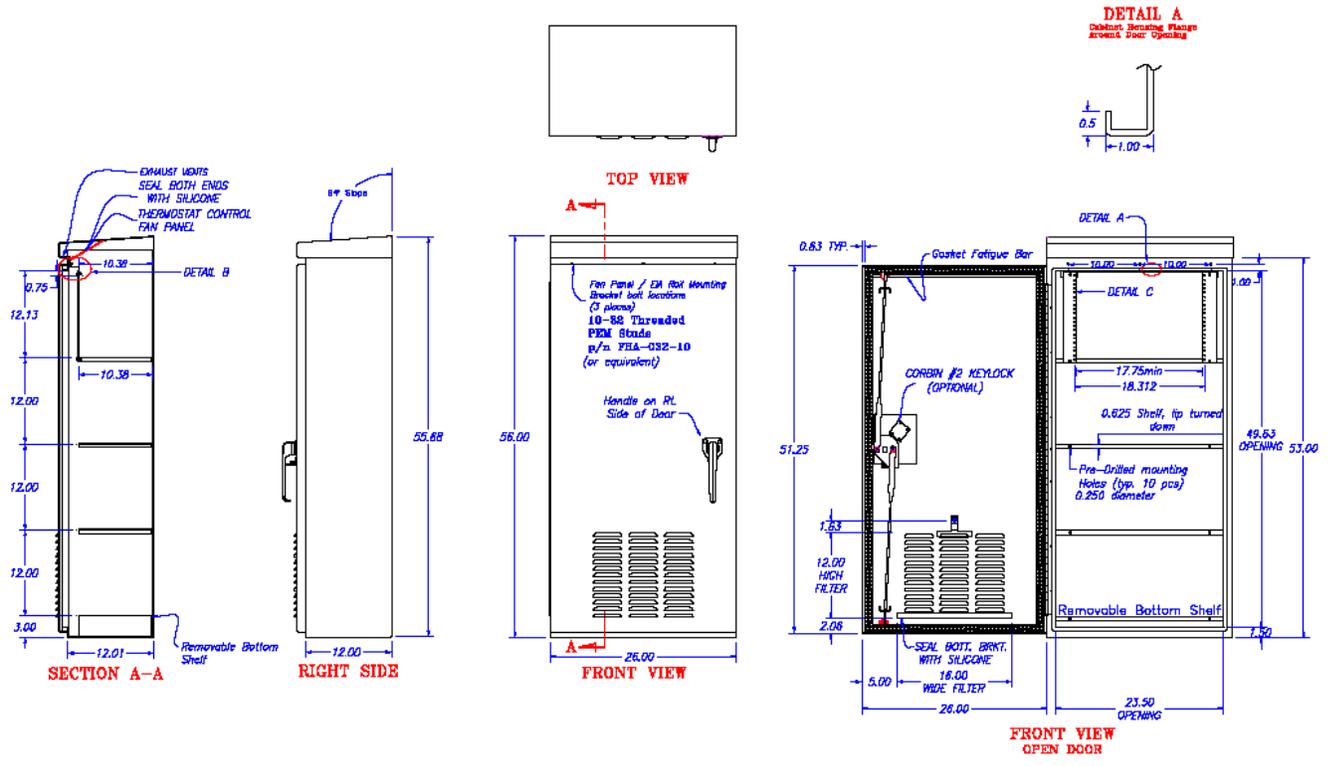


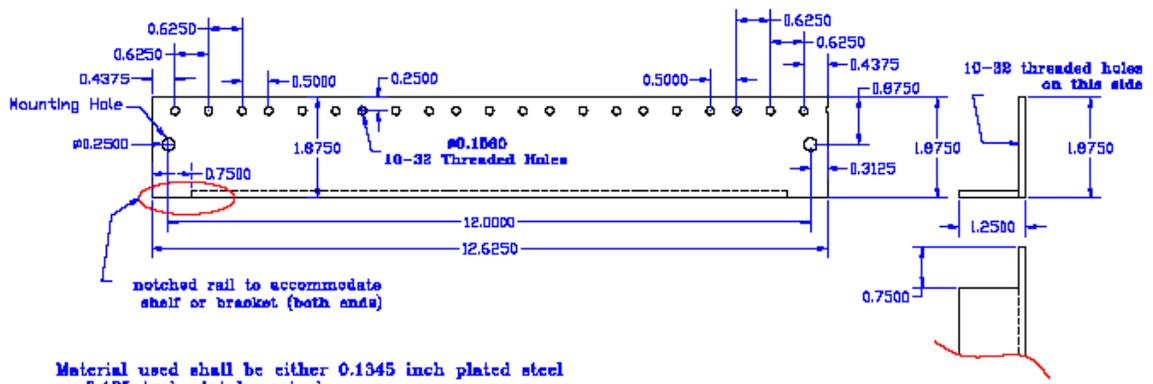
Figure 925-10 External BBS Cabinet Details

- e) Four shelves shall be provided. There shall be a minimum of 304.8mm (12") clearance between shelves. Each shelf shall be a minimum of 263.65mm (10.38") X 635.0mm (25"), and capable of supporting a minimum of 57kg (125 lbs.). Shelf edges shall be turned down on all four sides for support and to provide a flat top surface. Shelves shall be predrilled with EIA rail mounting holes. Shelves shall provide a vertical "passageway" for wiring in the rear of the cabinet on both the left and right.
- f) The bottom shelf shall be capable of being removed.

Figure 925-11 EIA Rail for Mounting Inverter or PTR inside External BBS Cabinet



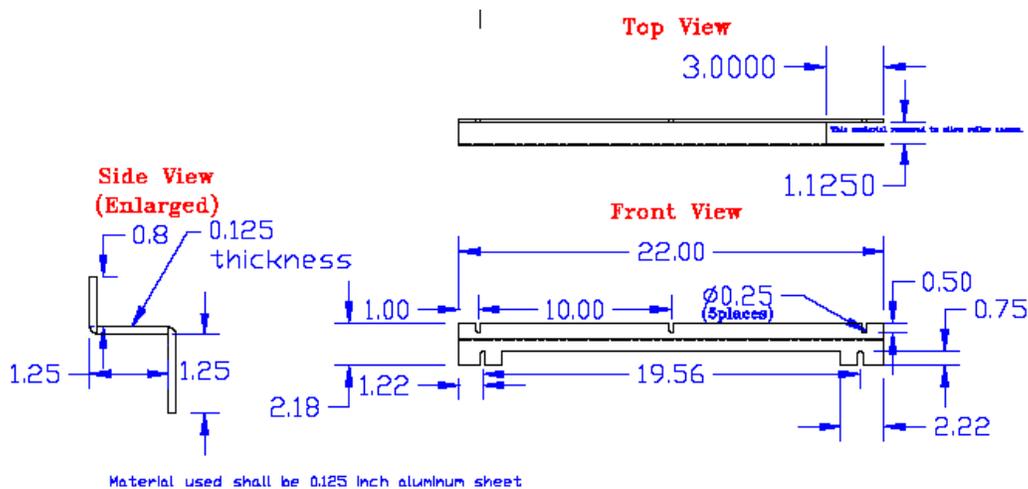
DETAIL C - EIA Angle Rail w/ EIA universal hole spacing
 Refer to EIA-310-B



Material used shall be either 0.1345 inch plated steel
 or 0.105 inch stainless steel.

- g) The External cabinet shall be ventilated through the use of louvered vents, filter, and one thermostatically controlled fan as per TEES Chapter 7 Section 2-Housings. The thermostat shall be accessible without removing the BBS controller.
- h) External cabinet fan shall be AC operated from the same line output of the Manual Bypass Switch that supplies power to the 332 Cabinet. A 2-position terminal block shall be provided on the fan panel, along with 3 meters (10 feet) of connected hookup wire.
- i) The door shall be attached to the cabinet through the use of either a continuous stainless steel piano hinge or four, two-bolts per leaf, hinges as per TEES Chapter 7 Section 2. The door shall use a padlock clasp or latch and lock mechanisms as described in the TEES, in order to lock the door.
- j) Two EIA angle rails, per Detail C, Figure 925-11, along with all necessary mounting hardware (4 sets of 10-32 bolts and nuts with captive washers) shall be provided with the external cabinet (not installed). Rails shall be symmetric to allow for installation on either right or left sides of the cabinet. Mounting holes and bracket shall allow for EIA rail installation at any location in the external cabinet. The EIA mounting angle nominal thickness shall be either 0.1345 inch (3.4163mm) plated steel or 0.105 inch (2.667mm) stainless steel.
- k) EIA rail mounting bracket shall be of continuous, one-piece design bolted into the cabinet to provide adequate support for rail-mounted equipment. See Figure 925-12.
- l) Pressed in, flush-head threaded screw posts shall be inserted into the front face of the cabinet enclosure top sill. These threaded posts shall be used to mount both the fan panel and the EIA rail-mounting bracket. The screw posts shall be #10-32 thread size stud 0.625 inches in length. Refer to Figure 925-10, front views for mounting detail.

Figure 925-12 EIA Rail Mounting Bracket for Mounting EIA Rails inside External BBS Cabinet



3. Maintenance, Displays, controls and Diagnostics
 - a. The BBS shall include a display and /or meter to indicate current battery charge status and conditions.
 - 1) The BBS shall provide voltmeter standard probe input-jacks (+) and (-) to read the exact battery voltage drop at the inverter input.
 - 2) The BBS shall include a 0 to 100% battery capacity LED indicator.
 - b. The BBS shall have lightning surge protection compliant with IEEE/ANSI C.62.41.
 - c. The BBS shall be equipped with an integral system to prevent battery from destructive discharge and overcharge.
 - d. The BBS and batteries shall be easily replaced with all needed hardware and shall not require any special tools for installation.
 - e. The BBS shall include a front-panel event counter display to indicate the number of times the BBS was activated and a front-panel hour meter to display the total number of hours the unit has operated on battery power. Both meters shall be resettable.

- f. Manufacturer shall include a set of equipment lists, operation and maintenance manuals, and board-level schematic and wiring diagrams of the BBS, and the battery data sheets. Manual shall conform to TEES August 16, 2002, Chapter 1, Section 1.2.4.2.
 - g. The BBS shall be equipped to communicate via Ethernet connection.
4. Battery System
- a. Individual batteries shall be:
 - 1) Voltage rating: 12V type
 - 2) Group size: 24 maximum
 - 3) Batteries shall be easily replaced and commercially available off the shelf.
 - b. Batteries used for BBS shall consist of 4 to 8 batteries with a cumulative minimum rated capacity of 240 amp-hours.
 - c. Batteries shall be deep cycle, sealed prismatic lead-calcium based AGM/VRLA (Absorbed Glass Mat/ Valve Regulated Lead Acid).
 - d. Batteries shall be certified by the manufacturer to operate over a temperature range of – 25 °C (-13F) to + 71°C (+160 F).
 - e. The batteries shall be provided with appropriate interconnect wiring and corrosion-resistant mounting trays and/or brackets appropriate for the cabinet into which they will be installed.
 - f. Batteries shall indicate maximum recharge data and recharging cycles.
 - g. Battery Harness
 - 1) Battery interconnect wiring shall be via two-part modular harness.
 - 2) Part I shall be equipped with red (+) and black (-) 12 inch (30.48 cm) cabling that can be permanently connected to the positive and negative posts of each battery. Each red and black pair shall be terminated into an Anderson Power Pole Connector or AMP Power Series Connector or equivalent style connector.
 - 3) Part II shall be equipped with the mating Power Pole style connector for the batteries and a single, insulated Power Pole style connection to the inverter/charger unit. Harness shall be fully insulated and constructed to allow batteries to be quickly and easily connected in any order to ensure proper polarity and circuit configuration.
 - 4) Power Pole style connectors may be either one-piece or two-piece. If a two-piece connector is used, a locking pin shall be used to prevent the connectors from separating.
 - 5) The length of the battery interconnect harness (Part II) shall be a minimum of 60 inches (152.4 cm) from the Inverter/Charger plug to the first battery in the string. The lateral length of the harness between battery connectors shall be a minimum of 12 inches (30.48 cm).
 - 6) All battery interconnect harness wiring shall be UL Style 1015 CSA TEW or Welding Style Cable or equivalent, all of proper gauge with respect to design current and with sufficient strand count for flexibility and ease of handling.
 - 7) Battery terminals shall be covered and insulated with molded boots so as to prevent accidental shorting.

B. Fabrication

Refer to Subsection 925.2.04.B.1 for controller cabinet minimum fabrication Specifications.

C. Acceptance

General Provisions 101 through 150.

Each BBS shall be manufactured in accordance with a manufacturer Quality Assurance (QA) program. The QA program shall include two Quality Assurance procedures: (1) Design QA and (2) Production QA. The Production QA shall include statistically controlled routine tests to ensure minimum performance levels of BBS units built to meet this specification and a documented process of how problems are to be resolved. The manufacturer, or an independent testing lab hired by the manufacturer, shall perform Design Qualification Testing on new BBS system(s) offered, and when any major design change has been implemented on an existing design. A major design change is defined as any modification, material, electrical, physical or theoretical, that changes any performance characteristics of the system, or results in a different circuit configuration. Where a dispute arises in determining if a system is a new design or if the system has had a major design change, the State will make the final determination if Design Qualification Testing is required prior to production consideration.

Production Quality Control tests shall be performed on each new system prior to shipment. Failure to meet this requirements shall be cause for rejection. The manufacturer shall retain test results for seven years. Each BBS shall be given a minimum 100-hour burn-in period to eliminate any premature failures. Each system shall be visually inspected for any exterior physical damage or assembly anomalies. Any defects shall be cause for rejection.

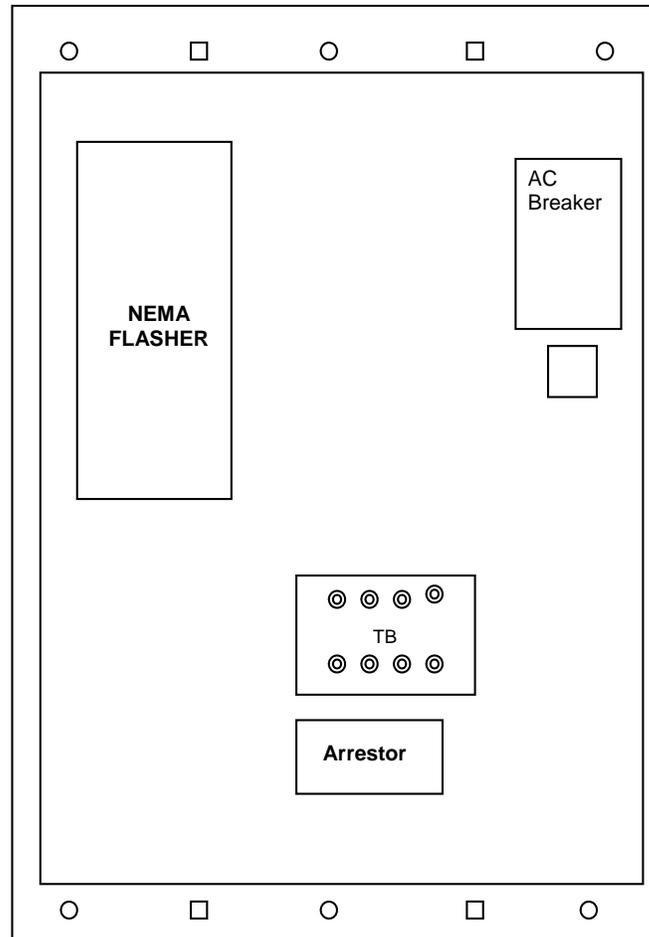
D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties. Manufacturers shall provide a two (2) year factory-repair warranty for parts and labor on the BBS from date of acceptance by the Department. Batteries shall be warranted for full replacement for the first year and 50% discount off the original purchase price for the second year from date of purchase. The warranty shall be included in the total bid price of the BBS.

925.2.07 Flashing Beacon Assembly

A. Requirements

This specification is for a flashing signal cabinet, which consists of an aluminum cabinet containing a flasher assembly, Field connection terminal block, surge arrester and circuit breaker wired in a manner to operate flashing beacons. Refer to Figure 925-13.



Note: Front view of cabinet Door Assembly not shown
No scale

Figure 925-13—Typical Flashing Signal Cabinet Layout

1. Cabinet Dimensions

Supply a NEMA Type 3R cabinet assembly with the following exterior dimensions:

	<u>Minimum</u>	<u>Maximum</u>
Height	14 inches (350 mm)	18 inches (450 mm)
Width	10 inches (250 mm)	14 inches (350 mm)
Depth	7 inches (175 mm)	10 inches (250 mm)

2. Flasher Unit

Supply a standard plug in two circuits NEMA flasher.

Ensure that the flasher is of all solid state construction, meets the requirements of the NEMA Standards and is rated at a minimum of 10 A per circuit.

Ensure that the flasher utilizes zero voltage turn-on and turn-off current and is capable of dimming outputs.

3. Surge Arrester

Supply a flasher cabinet that incorporates an AC surge arrestor to protect the internal components from lightning and over voltages on the AC service input.

The requirements for the surge arrestor are:

Two Stage Arrestor	
Peak Surge Current	20000 A
Peak Surge Voltage @ 20KA	280 V
Clamp Voltage	280 V @ 20 kA
Continuous AC Voltage	120 V AC RMS
Response Time	<5 nsec
Operating Temp.	-40 °F to 185 °F (-40 °C to 85 °C)

4. Circuit Breaker

Include a 15 A circuit breaker in the cabinet. The circuit breaker shall have the following characteristics.

- Thermal Magnetic 1 pole 120/240 VAC at 50/60 Hz 15 A
- Interrupting Rating of 10KA at 48 VDC
- Wire Size 14 to 2 AWG
- 35 MM Din Rail mounting

5. Terminal Block

Include a four position terminal block in the cabinet for making field connections. Properly label all field terminal connections.

6. Construction

Assemble the flasher assembly, terminal block, surge arrestor and circuit breaker in the cabinet as shown on the attached drawing.

Wire all components together as a working unit, thus requiring only field connections to and from the AC power and flashing beacons.

B. Fabrication

Refer to Subsection 925.2.04.B.1 for controller cabinet minimum fabrication specifications.

C. Acceptance

General Provisions 101 through 150.

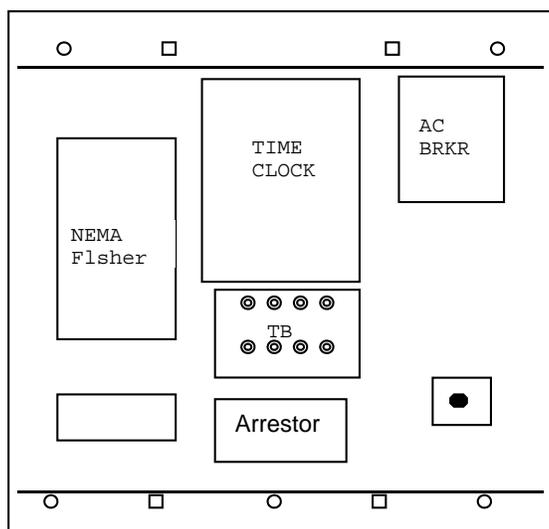
D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.08 Flashing Signal Cabinet With Time Clock

A. Requirements

This specification is for a flashing signal cabinet with time clock which consists of an aluminum cabinet containing a flasher assembly, time clock, field connection terminal block, surge arrestor and circuit breaker wired in a manner to operate school flashing beacons. Refer to Figure 925-14.



Note: Front view of cabinet Door Assembly not shown

No scale

Figure 925-14—Typical Flashing Cabinet with Time Clock Cabinet Layout

1. Cabinet Dimensions

Supply a NEMA Type 3R cabinet assembly with the following exterior dimensions:

	Minimum	Maximum
Height	14 inches (350 mm)	18 inches (450 mm)
Width	10 inches (250 mm)	14 inches (350 mm)
Depth	7 inches (175 mm)	10 inches (250 mm)

2. Flasher Unit

Supply a standard plug in, two circuits NEMA flasher.

Ensure that the flasher is of all solid state construction, meets the requirements of the NEMA Standards and is rated at a minimum of 10 A per circuit.

Ensure that the flasher utilizes zero voltage turn-on and turn-off current and be capable of dimming outputs.

3. Time Switch

Supply a time switch that meets the requirements of Subsection 925.2.09 of this specification.

4. Surge Arrestor

Supply flasher cabinets that incorporate an AC surge arrestor to protect the internal components from lightning and over voltages on the AC service input.

The requirements of the surge arrestor are as follows:

Two Stage Arrestor

Peak Surge Current 20000 A

Peak Surge Voltage @ 20KA 280 V

Clamp Voltage 280 V @ 20 kA

Continuous AC Voltage 120 V AC RMS

Response Time <5 nsec

Operating Temp. -40 °F to 185 °F (-40 °C to 85 °C)

5. Circuit Breaker

Include a 15 A circuit breaker in each cabinet. The circuit breaker shall have the following characteristics.

- Thermal Magnetic 1 pole 120/240 VAC at 50/60 Hz 15 A

- Interrupting Rating of 10KA at 48 VDC
- Wire Size 14 to 2 AWG
- 35 MM Din Rail mounting

6. Terminal Block

Include a four position terminal block in each cabinet for making field connections. Properly label all field terminal connections.

7. Construction

Assemble the flasher assembly, terminal block, surge arrestor and circuit breaker in the cabinet as shown on the attached drawing.

Wire all components together as a working unit, thus requiring only field connections of the AC power and flashing beacons.

B. Fabrication

Refer to Subsection 925.2.04.B.1 for controller cabinet minimum fabrication Specifications.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.09 Time Clock

A. Requirements

Supply time clocks that are single circuit, calendar programmable, solid state, fully self-contained units (RTC AP 22 or Eltec TC18 or equivalent) that meet the following Specifications:

1. Alphanumeric liquid crystal display.
2. Automatic daylight savings time and leap year compensation. Changes in the daylight savings time program made through the keypad do not require hardware modification.
3. Minimum twenty-four (24) hour capacitive back up. Battery back up is not acceptable.
4. Keypad entry programming without the use of any external devices such as a PC, external programming unit, another time switch, etc.
5. Operate on 95 to 135 V AC, 60 Hz line current.
6. SPDT relay output rated at 15 A.
7. Maximum size of 4.75 inches (121 mm) wide, 10.375 inches (2636 mm) high and 2 inches (50 mm) deep.
8. A programming manual is to be included with each unit.
9. Ability to do program transfer from unit to unit. Include program transfer cable with unit.
10. Ability to run minimum six (6) different day plans and minimum twenty five (25) different annual exception plans. Temperature range of -30° F (-34° C) + 165° F (74° C).

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.10 Self Tuning Loop Detector

A. Requirements

This specification sets forth the minimum acceptable design, operational and functional performance requirements for multi-channel, inductive loop vehicle detection systems.

1. General Requirements
 - a. Mounting

Ensure that the unit is configured for rack mount insertion into a NEMA (TS 1 or TS 2) card rack and/or CALTRANS Type 2070 cabinet input file.
 - b. Environmental

Ensure that the unit is in full compliance with the environmental tests, transient tests and size requirements of NEMA standard TS-1 Section 15, TS-2 Section 6.5 and the California Type 2070 Specifications.

Provide documentation from an independent laboratory, which certifies that the unit is in compliance with the above Specifications.
 - c. LED Indicator

Ensure that each channel includes two high visibility LED indicators; one for the detect state and the second to indicate the status of the fault monitor.
2. Operational Requirements
 - a. Tuning

Supply units that are fully digital and self-tuning.

Ensure that each channel of the unit can automatically tune to any loop and lead in combination within two (2) seconds of application of power or when a reset signal is received.

Ensure that the tuning circuit is designed so that drift, caused by environmental changes or changes in applied power, does not cause false actuations.
 - b. Scanning

Supply units that sequentially scan each channel (only one channel energized at any given time) to eliminate crosstalk from multiple loops in adjacent lanes and/or allow overlapped loops for directional control and/or allow use of multi-conductor homerun cable when connected to the same detector unit.
 - c. Sensitivity Setting

Ensure that each channel is equipped with front panel selectable sensitivity settings in presence and pulse modes.
 - d. Frequency

Supply units that have a minimum of three switch selectable operating frequencies.
 - e. Inductance Range

Ensure that each channel can tune to an inductive load from 50 to 2000 microhenries with a Q factor > 5.
 - f. Grounded Loops

Ensure that each channel can continue to operate with poor quality loop systems ($Q > 2$) including those that have a single point short to ground.
 - g. Fault Monitoring

Supply units that constantly monitor the operation of each channel.

Ensure that the unit detects shorted loops, open circuit loops or sudden changes in inductance (>25% of nominal).

Ensure that each type of fault is indicated on a fault LED by a unique sequence of flashes until the fault is rectified.

Ensure that while the channel is in the fault condition, the channel output remains in the detect state.

When the fault is rectified, the fault LED continues to emit the sequence signifying the last fault detected, but the detect LED and output returns to normal operation.
 - h. Failsafe Output

Ensure that each channel output generates a continuous solid state output to the controller when power to the detector is removed.
 - i. Operational Modes

Supply units with each channel selectable for either pulse or presence modes and that meet the following requirements:

 - Pulse Mode
 - This setting provides a single output pulse (125 ms +/- 25) in response to a vehicle entering the loop.

- If a vehicle remains in the sensing zone in excess of two (2) seconds, the unit "tunes out" said vehicle.
- The channel is then capable of detecting another vehicle entering the same detection zone.
- Presence Mode
- The presence hold time is a minimum of four (4) minutes for small vehicles (motorcycles) and a minimum of sixty (60) minutes for automobiles.
- Ensure that the unit tunes out of continuous peak hour traffic over long or multiple small loops as long as there is vehicle motion in the sensing zone every ten (10) minutes.

j. Resets

Ensure that the channels are manually resettable by removing the power momentarily.

Ensure that the channels reset remotely when the voltage on Pin C falls below 8 V DC for a period > 15 μ s, and that the unit resumes normal operation within four (4) seconds after the application of power or after a reset signal of 15 μ s.

k. Field Tuning

Ensure that field adjustments to the operation of the detector do not require the use of a meter, circuit changes, special software or any substitutions, modifications or additions to the unit.

3. Performance Requirements

If testing should be required, provide the Department with a test unit and/or software within ten (10) calendar days of the request.

Should the unit fail to meet the design and/or performance requirements of this specification, the unit will be rejected.

Ensure that the units meet the following requirements:

- Capable of detecting passage, holding presence and accurately counting all types of licensed motor vehicles when connected in various loop configurations and lead-in combinations without detecting vehicles in adjacent lanes.
 - Typical Loop Configurations with Lead-in of 5 feet (1.5 m) to 1,500 feet (1000 m) are:
 - 6 feet x 6 feet (1.8 m x 1.8 m)
 - 6 feet x 20 feet (1.8 m x 6 m)
 - 6 feet x 40 feet [(1.8 m x 12 m) standard or quadrupole]
- Capable of responding to an inductance change of 0.02% and sense vehicles at speeds of up to 80 mph (130 km/h).
- Not detect vehicles, moving or stopped, at distances greater than three feet for any loop perimeter.
- Detect all vehicles over multiple turn and/or multiple loops that may be connected in series, parallel or series/parallel with homerun lengths from <5 feet (1.5 m) to > 1,500 feet (1,000 m).

4. Optional Features

In addition to the requirements listed in the previous sections, the units may be requested with any combination of the following optional features:

a. Option 1- Timing Features - Delay & Extension

When this option is specified, ensure that the unit incorporates the following features:

1) Delay Timing

Minimum selectable delay time of 1 to 30 seconds in minimum 1-second increments for each channel.

2) Extension Timing

Minimum selectable extension time of 0.5 to 10 seconds in minimum 0.5-second increments for each channel.

b. Option 2 - Advanced Features

When the option for advanced features is specified, supply units that incorporate the following advanced features:

1) Serial Port Interface

When the serial port interface is specified, equip the detector with a front and rear panel RS 232 port for the transmission of data. Provide Windows 95 compatible software for interfacing with the detector.

2) PC Interface

Ensure that PC software, when connected directly to the unit through the front panel RS 232 port, provides a screen to display the following loop system operating characteristics, on a per channel basis, for system setup, data collection and diagnostics.

- Loop Status
- Loop Inductance (μH)
- Loop Frequency (kHz)
- Inductance Change (nH)
- Last Fault: Open, Shorted, >25% L
- Fault Occurrence: Date & Time
- Vehicle Count

3) Speed, Volume & Occupancy

The software, when connected directly to the unit, is capable of collecting and storing speed, volume and occupancy data from each detector channel.

The software allows assignment of loop-to-loop distances to enable accurate speed and vehicle length measurements.

The speed volume and occupancy information is uploaded and stored in the vendor-supplied software.

Upon request, supply the necessary information/protocols to allow the Department to write custom software to retrieve speed, volume and occupancy data.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.11 Loop Sealant

A. Requirements

Furnish and install loop sealant according to Subsection 833.2.09, "Polyurethane Sealant for Inductive Loops". For a list of sources, see QPL 75.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.12 Vehicle Signal Heads

A. Requirements

Supply vehicle signal heads that are 12 inches (300 mm) in diameter for traffic signal control applications. For ramp metering systems supply both 12 inches (300 mm) and 8 inches (200 mm) as per the Plans.

Ensure that the 8 inch (200mm) or 12 inch (300 mm) polycarbonate vehicle signal heads meet the current ITE specification on Vehicle Traffic Control Signal Heads with the following modifications and / or clarifications:

1. Unless otherwise approved by the Engineer or as noted on the Plans, supply signal heads with the following exterior color scheme:

- Signal Housing - Highway Yellow.
 - Front Face including Doors and Visors: Flat Black
2. Provide housing and housing door that are one piece injection molded ultraviolet and heat stabilized polycarbonate resin with the color impregnated in the material.
 3. Terminate the wiring from each signal section in the top section of the head assembly. Ensure that the cable jacket is a minimum of 6 inches inside the signal head assembly.
 4. Provide the appropriate Vehicle Signal LED Signal in each section either Circular or Arrow Module.
 5. Provide an effective seal with the LED module to make the assembly weather tight.
 6. Mount one aluminum reinforcing support plate in the top of the red section of each three and four section signal head for the installation of mounting hardware.
 7. All five section heads or heads equipped with 2-way mounting hardware shall have aluminum mounting support plates installed in the top and bottom of the red section/sections for mounting hardware.
 8. Install a support plate between each section of all signal heads. Place these plates such that there is a plate in the bottom of and/or top of any sections where sections adjoin to another section.
 9. Provide Signal Heads that use stainless steel hardware and are weather tight. Ensure signal heads that are supplied are sealed for mounting in all possible configurations.
 10. Provide Signal Heads that have housing door that “positively” latches using two eyebolts and wing nuts. Ensure the Signal door has hinge lugs molded on one side and two latch jaws are molded on the other side.
 11. Provide signal heads that provide a positive method of holding the lens such that the lens does not rotate. Ensure the lens is weather tight. Lens clips which do not apply firm pressure to the lens gasket to avoid rotation are not acceptable. When constructing side by side signal sections ensure that both doors can open at the same time (butterfly). When doors are open ensure that the door will remain attached to housing. Ensure bottom section has drainage holes.

B. Fabrication

Refer to ITE Standards for material composition and finish Specifications.

C. Acceptance

Refer to ITE Standards for material composition, finish Specifications, and wind loading requirements.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.13 Pedestrian Signal Head

A. Requirements

Provide each section with a visor encompassing the top and sides of the signal face of a size and shape adequate to shield the lens from external lighted sources.

An acceptable option is a “Z-crate” or louver type visor for mounting over the Pedestrian signal face.

Construct the housing of one piece cast aluminum alloy with two integrally hinge lugs, screw slots and openings at each end. Construct the door of one piece cast aluminum alloy with two hinge lugs cast on top of the door and two latch points cast on the bottom. Provide hinge pins of stainless steel to attach the door to the housing and two eye bolts and wing nuts on the other side of the door.

Ensure that the door is provided with a neoprene gasket capable of making a weather resistant, dustproof seal when closed. Supply Pedestrian signal heads with a black face and a yellow body, unless otherwise specified on the Plans.

Ensure that Pedestrian indications are distinguishable to the Pedestrian both day and night and at all distances from 10 feet (3 m) to the full width of the areas to be crossed.

Use symbols that are 12 inches (300 mm) high. Use only internal illumination.

Ensure that when illuminated, the “HAND” symbol is Portland Orange and the “PERSON” symbol is Lunar White, meeting the ITE Standards. Ensure that an opaque material obscures all areas of the face or lens, except for the message. Ensure that when not illuminated, the symbols are not to be distinguishable by Pedestrians at the far end of the crosswalk they control.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.14 Optically Programmed Signal Head

A. Requirements

Supply signal heads that permit the visibility zone of the indication to be determined optically and require no hoods or louvers.

The projected indication may be selectively visible or veiled anywhere within 15 degrees of the optical axis.

Ensure that no indication results from external illumination and that one light unit does not illuminate a second. The components of the optical system include the lamp, lamp collar, optical limiter-diffuser, and objective lens.

Ensure that the optical system accommodates projection of diverse, selected indications to separate portions of the roadway such that only one indication will be simultaneously apparent to any viewer.

Ensure that the projected indication conforms to ITE transmittance and chromaticity Standards.

1. Construction

- a. Provide an LED Lamp Module that is a direct replacement for the incandescent lamp. Ensure the Lamp modules are on the latest CALTRANS QPL for LED Programmed Visibility Modules. Ensure the unit provided operates over the voltage range of 80 to 135 VAC and the temperature range of -40 C (-40 F) to 74 C (165 F). Provide modules that conform to the applicable portions of section 925.2.15. Ensure the unit provides a minimum luminous intensity of 500 candela and does not exceed 18 watts at 25 C (77 F).

Couple the lamp to the diffusing element with a collar including a specular inner surface. The diffusing element may be discrete or integral with the convex surface of the optical limiter.

- b. Supply an optical limiter with an accessible imaging surface at focus on the optical axis for objects 900 to 1,200 feet (270 to 360 m) distance and permit an effective veiling mask to be variously applied as determined by the desired visibility zone.

Ensure that the optical limiter is provided with positive indexing means and is composed of heat-resistant glass.

- c. Ensure that the objective lens is a high-resolution planar incremental lens hermetically sealed within a flat laminate of weather resistant acrylic or approved equal.

Supply a lens that is symmetrical in outline and that may be rotated to any 90-degree orientation about the optical axis without displacing the primary image.

2. Mounting

- a. Supply signals that mount to standard 1.5 inch (38 mm) fittings as a single section, as a multiple section face, or in combination with other signals.

Provide signal sections with an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal while maintaining a common vertical axis through couplers and mounting.

Ensure that terminal connections permit external adjustment about the mounting axis in 5-degree increments.

- b. Ensure that the signal is mountable with ordinary tools and capable of being serviced with no tools.

Supply attachments such as back plates or adapters that conform and readily fasten to existing mounting surfaces without affecting water and light integrity of the signal. Supply heads with tri-studs for mounting.

3. Electrical

Supply lamp fixtures that comprise a separately accessible housing and integral lamp support indexed ceramic socket and self-aligning, quick release lamp retainer.

Ensure that electrical connection between case and lamp housing can be accomplished with an interlock assembly, which disconnects lamp holder when opened. Include a covered terminal block for clip or screw attachment of lead wires for each signal section.

Use concealed No. 18 AWG, stranded and coded wires to interconnect all sections to permit field connection within any section.

4. Photo Controls

Ensure that each signal includes integral means for regulating its intensity between limits as a function of the individual background illumination.

Ensure that lamp intensity is not less than 97% of uncontrolled intensity at 10 750 lux, and reduces to 15 + 2% of maximum at less than 10.75 lux.

Ensure that response is proportional and essentially instantaneous to any detectable increase of illumination from darkness to 10 750 lux, and damped for any decrease from 10 750 lux.

Ensure that the intensity controller is comprised of an integrated, directional light sensing and regulating device interposed between lamp and line wires.

Ensure that it is compatible with 60 Hz input and responsive within the range 105 to 135 V AC.

Output may be phase controlled, but ensure that the device provides nominal terminal impedance of 1,200 Ω open circuit and a corresponding holding current.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.15 LED Signal Modules

A. Requirements

This specification covers Type 1 Light Emitting Diode (LED) red, green and yellow modules for vehicle signals for both Circular and Arrow indications. It also covers LED Pedestrian "HAND & PERSON" signal modules.

1. General Requirements All Modules

Ensure that Type 1 LED signal module include a LED circuit board with LEDs and required circuit components, 36 inch (900 mm) 16 AWG wire leads with strain relief and spade terminals, a rigid housing, and a one piece neoprene gasket.

Supply Type 1 LED signal modules that are watertight when mounted in the traffic signal housing.

Submit life data on the LEDs from the LED Signal Module manufacturer to calculate the expected useful life.

Supply modules with permanent markings of date of manufacture and date of installation.

Ensure that the Type 1 LED signal modules utilize the same mounting hardware that is used to secure the incandescent lens and gasket assembly.

2. Optical All Modules

Provide test data from an independent laboratory to verify that the performance of the product meets current ITE requirements.

Ensure that the individual LEDs are wired such that a catastrophic failure of one LED will result in the loss of not more than 5% of the signal module light output.

The failure of a single LED in a string or cluster of LED's causes loss of light from only that LED, not the entire string or indication.

Provide control circuitry that prevents the current flow through the LEDs in the "off" state to avoid any false indications as may be perceived by the human eye during daytime and nighttime hours.

Ensure that the LED signal module is operationally compatible with existing or new supplied conflict monitors (NEMA TS-1, NEMA TS-2, Model 210, Model 2010, ITS Cabinet CMU and AMU)..

Ensure that the LED Signal Module is operationally compatible with existing or new supplied load switches.

3. Electrical All Modules

Supply LED signal modules that operate over the temperature range of -40 °F to 165 °F (-40 °C to 74 °C).

Ensure that the power factor is 90% or greater, at nominal rated voltage, at 77 °F (25 °C), after 60 minutes of operation. Provide modules that do not exceed the maximum power consumption as shown in Table 925-18.

Table 925-18 Maximum Power Consumption (in Watts) at 25 C (77 F) & 74 C (165 F)						
Vehicle Indications	Red		Yellow		Green	
Temperature	25 C	74 C	25 C	74 C	25 C	74 C
12 Inch (300 mm) Circular	11	17	22	25	15	15
8 Inch (200 mm) Circular	8	13	13	16	12	12
12 Inch (300 mm) Arrow	9	12	10	12	11	11
Pedestrian Indications	Hand				Man	
Temperature	25 C	74 C	25 C	74 C	25 C	74 C
12 Inch (300 mm)	10	12			9	12

Ensure that the total harmonic distortion (THD) is less than 20% at rated voltage, at 77 °F (25 °C) and that all LED traffic signal modules are in compliance with FCC noise regulations.

Ensure that the LED signal modules operate on line voltage, 120 V AC nominal, and are able to operate over the voltage range of 80 V AC to 135 V AC. Power Supply must be integral to the module.

Provide transient voltage suppression rated at 1,500 W for 1 millisecond and fusing with a maximum rating of 2 A to minimize the effect and repair cost of an extreme over voltage situation or other failure mode.

Ensure the lens of the modules that are polymeric and are not frosted have a surface coating to provide front surface abrasion resistance. Ensure the Red and Yellow section module lens are tinted to correspond with the wavelength (chromaticity) of the LED. Ensure Green Section modules are clear.

Ensure the modules allow a reduction of the intensity of the light output in response to an input from the traffic signal controller. Ensure the minimum light output when dimmed is not less than 30% of the minimum maintained luminous intensity as defined in the applicable Signal Head Module.

4. Circular Signal Modules

Supply LED Circular Signal Modules that fit in standard incandescent vehicle traffic signal housings and meet the Performance Specification of the ITE Vehicle Traffic Control Signal Heads: LED Circular Signal Supplement. In case of conflict, this specification shall govern. Before delivery of any modules supply certification that module is to be in compliance with these specifications. In addition substantiating documentation must be supplied from an independent test laboratory to show the product has passed design qualification testing in accordance with section 6.4 of the ITE Vehicle Traffic Control Signal Heads: LED Circular Signal Supplement. Ensure the report includes a Minimum Maintained Luminous Intensity chart for the module being provided that uses the same horizontal and vertical angles as shown in Table 1 of the ITE Vehicle Traffic Control Signal Heads: LED Circular Signal Supplement. Ensure all modules are provided with a signed copy of the production and test and inspection as detailed in section 6.3 of the ITE Vehicle Traffic Control Signal Heads: LED Circular Signal Supplement.

Supply lenses for that are made of ultraviolet stabilized polycarbonate. Ensure that the external lens surface is smooth, with no raised features, to, minimize the collection of dirt, diesel smoke, and other particulate contaminates, and to facilitate periodic cleaning.

Ensure that Circular Signal Modules have prominent and permanent markings to designate the proper orientation of the signal module in the traffic signal housing. This marking should be an up arrow or the word “UP” or “TOP”.

Ensure Circular Signal Module meets the photometric requirements as indicated and described in the ITE VTC SH LED Circular Signal Supplement.

Supply Red and Yellow LEDs that utilize AlInGaP technology, either AS (Absorbing Substrate or TS (Transparent Substrate) and do not exhibit degradation of more than 30% of their initial light intensity following accelerated life testing (operating at 185 F (85 C) and 85% humidity, for 1000 hours). AlGaAs technology is not acceptable.

Supply Green LEDs that utilize gallium nitride technology.

5. Vehicle Arrow Signal Modules

Supply LED Arrow Signal Modules that fit in standard incandescent vehicle traffic signal housings and meet the Performance specification of ITE Vehicle Traffic Control Signal- LED Vehicle Arrow Traffic Signal Supplement. Ensure that Arrow Signal Modules provided are omni directional and marked as OD so that they may be rotated at any angle. Ensure the Arrow modules Photometrics support the luminous intensity as indicated in table 925-19.

Before delivery of any modules supply certification that module is to be in compliance with these specifications. In addition substantiating documentation must be supplied from an independent test laboratory to show the product has passed design qualification testing in accordance with section 6.4 of the ITE Vehicle Traffic Control Signal Heads: LED Circular Signal Supplement. Ensure the report includes a Minimum Maintained Luminous Intensity chart for the module being provided that uses the same horizontal and vertical angles as shown in Table 1 of the ITE Vehicle Traffic Control Signal Heads: LED Vehicle Arrow Traffic Signal Supplement. Ensure all modules are provided with a signed copy of the production and test and inspection as detailed in section 6.3 of the ITE Vehicle Traffic Control Signal Heads: LED Vehicle Arrow Traffic Signal Supplement.

Supply lenses for that are made of ultraviolet stabilized polycarbonate. Ensure that the external lens surface is smooth, with no raised features, to, minimize the collection of dirt, diesel smoke, and other particulate contaminates, and to facilitate periodic cleaning. Supply Red and Yellow LEDs that utilize AlInGap technology, either AS (Absorbing Substrate or TS (Transparent Substrate) and do not exhibit degradation of more than 30% of their initial light intensity following accelerated life testing (operating at 185° F (85° C) and 85% humidity, for 1000 hours). AlGaAs technology is not acceptable.

Supply Green LEDs that utilize gallium nitride technology.

Bi-Modal signal heads shall meet the standards for both Yellow and Green LEDs mentioned above.

Supply LED Arrow Signal Modules that fit in standard incandescent vehicle traffic signal housings and meet the "ITE Vehicle Traffic Control Signal Heads Part 3: Light Emitting Diode (LED) Vehicle Traffic Signal Modules". Use Table 925-19 for all references to minimum maintained Intensity values. Ensure the LED arrow modules meet the required luminous intensity as shown in Table 925-19.

Table 925-19 Minimum Maintained Luminous Intensity Values for Arrow LED Indications									
Angle					Angle				
Ver	Hor	12 inch (300 mm)			Ver	Hor	12 inch (300 mm)		
+	+ or -	Red	Yellow	Green	-	+ or -	Red	Yellow	Green
2.5	2.5	56.8	141.6	73.9	2.5	2.5	56.8	141.6	73.9
	7.5	47	117.1	61.1		7.5	47	117.1	61.1
	12.5	32.1	80.1	41.8		12.5	32.1	80.1	41.8
	17.5	18.2	45.3	23.7		17.5	18.2	45.3	23.7
	22.5	8.5	21.2	11.1		22.5	8.5	21.2	11.1
	27.5	3.3	8.2	4.3		27.5	3.3	8.2	4.3
7.5	2.5	47	117.1	61.1	7.5	2.5	47	117.1	61.1
	7.5	38.9	97	50.6		7.5	38.9	97	50.6
	12.5	26.7	66.5	34.7		12.5	26.7	66.5	34.7
	17.5	15.1	37.7	19.7		17.5	15.1	37.7	19.7
	22.5	7.1	17.7	9.2		22.5	7.1	17.7	9.2
	27.5	2.8	6.9	3.6		27.5	2.8	6.9	3.6
12.5	2.5	32.1	80.1	41.8	12.5	2.5	32.1	80.1	41.8
	7.5	26.7	66.5	34.7		7.5	26.7	66.5	34.7
	12.5	18.3	45.7	23.9		12.5	18.3	45.7	23.9
	17.5	10.5	26.1	13.6		17.5	10.5	26.1	13.6
	22.5	5.0	12.4	6.4		22.5	5.0	12.4	6.4
	27.5	-	-	-		27.5	-	-	-
17.5	2.5	18.2	45.3	23.7	17.5	2.5	18.2	45.3	23.7
	7.5	15.1	37.7	19.7		7.5	15.1	37.7	19.7
	12.5	10.5	26.1	13.6		12.5	10.5	26.1	13.6
	17.5	6.0	15.0	7.8		17.5	6.0	15.0	7.8
	22.5	2.9	7.2	3.8		22.5	2.9	7.2	3.8
	27.5	-	-	-		27.5	-	-	-
22.5	2.5	8.5	21.2	11.1	22.5	2.5	8.5	21.2	11.1
	7.5	7.1	17.7	9.2		7.5	7.1	17.7	9.2
	12.5	5.0	12.4	6.4		12.5	5.0	12.4	6.4
	17.5	2.9	7.2	2.8		17.5	2.9	7.2	2.8
	22.5	-	-	-		22.5	-	-	-
	27.5	-	-	-		27.5	-	-	-
27.5	2.5	3.3	8.2	4.3	27.5	2.5	3.3	8.2	4.3
	7.5	2.8	6.9	3.6		7.5	2.8	6.9	3.6
	12.5	-	-	-		12.5	-	-	-
	17.5	-	-	-		17.5	-	-	-
	22.5	-	-	-		22.5	-	-	-
	27.5	-	-	-		27.5	-	-	-

6. Pedestrian Signal Modules

Supply LED Pedestrian Traffic Signal Modules that fit in standard pedestrian one section signal head manufactured in accordance with the ITE Pedestrian Traffic Control Signal Indications (PTCSI) housings and meet the ITE Pedestrian Traffic Signal Modules specification.

Ensure that the Pedestrian Indications for the “Hand” and “Man” are filled in so as to provide a solid indication. Do not supply Pedestrian Indications for the Hand and Man that are “outlines”.

Ensure that Pedestrian Signal Modules have prominent and permanent markings to designate the proper orientation of the signal module in the pedestrian signal housing. This marking should be an up arrow or the word “UP” or “TOP”.

Ensure Pedestrian Signal Module meets the photometric requirements as indicated and described in the ITE PTCSI LED Pedestrian Traffic Signal Module Specification.

Supply Portland Orange LEDs that utilize AlInGap technology, either AS (Absorbing Substrate or TS (Transparent Substrate) and do not exhibit degradation of more than 30% of their initial light intensity following accelerated life testing (operating at 185° F (85° C) and 85% humidity, for 1000 hours). AlGaAs technology is not acceptable.

Supply White LEDs that utilize InGaN technology.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Ensure that LED traffic signal modules and LED Pedestrian modules are performance warranted to be in compliance with the minimum intensity values as shown in Table 925-19. Provide independent laboratory test results indicating that LED indications satisfy the minimum intensity Standards for LED traffic signal modules, measured at 120 V AC and 165 °F (74 °C), for a period of five (5) years.

Ensure that the manufacturer's name, part number, date code, and electrical characteristics of the LED signal module is visible on the assembly, and that each LED signal module is identified for warranty purposes.

925.2.16 LED Pedestrian and Countdown Signal Module

A. Requirements

This specification covers LED traffic signal module designed as a retrofit replacement for the message bearing surface of nominal 16" x 18" (400 mm x 450 MM) traffic signal housing built to the PTSCI Standard. The message bearing surface of the module consists of an overlapping "Hand" and "Man" Symbols with a numerical display of numbers from 00 to 99.

1. General Requirements

Ensure that the unit supplied meets the applicable portions of section 925.15 of this specification.

Ensure that the message numbers "00" to "99" are a minimum of 9 inches (228 mm) in height and consist of two rows of LEDs.

Ensure the module fits in the Pedestrian Signal Housing without modification to the housing and requires no special tools for installation.

Supply LED signal modules that are watertight when mounted in the traffic signal housing.

Supply life data from the LED Signal Module manufacturer to calculate the expected useful life

Supply modules with permanent markings for date of manufacture and date of installation.

2. Optical

Provide test data from an independent laboratory to verify that the performance of the product meets current ITE requirements.

Ensure that the individual LEDs are wired such that a catastrophic failure of one LED will result in the loss of not more than 5% of the signal module light output.

The failure of a single LED in a string causes loss of light from only that LED, not the entire string or indication.

Provide control circuitry that prevents the current flow through the LEDs in the "off" state to avoid any false indications as may be perceived by the human eye during daytime and nighttime hours.

Ensure that the LED signal module is operationally compatible with existing or new supplied conflict monitors (NEMA TS-1, NEMA TS-2, Model 210, Model 2010, ITS Cabinet CMU and AMU).

Ensure that the LED Signal Module is operationally compatible with existing or new supplied load switches.

Ensure that the intensity of the LED signal module does not vary by more than 10% over the allowable voltage range as specified in the electrical section below.

Ensure that the LED signal modules maintain not less than 90% of the required intensity, as defined by the ITE intensity Standards for LED traffic signal modules.

Ensure that each module provides an average luminous of at least 3750 candela per square meter of lighting surface for the "Hand" and 5300 candela per square meter for the Man symbol.

Ensure this over the temperature range of -40 °F to 165 °F (-40 °C to + 74 °C) at 120 V AC, when new and after four (4) years of field installation.

Provide an exterior lens which is uniform and frosted to reduce sun phantom effect.

3. Electrical

Supply LED signal modules that operate over the temperature range of –40 °F to 165 °F (-40 °C to 74 °C).

Ensure that the power factor is 90% or greater, at nominal rated voltage, at 77 °F (25 °C), after 60 minutes of operation.

Ensure that the total harmonic distortion (THD) is less than 20% at rated voltage, at 77 °F (25 °C) and that all LED traffic signal modules are in compliance with FCC noise regulations.

Ensure that the LED signal modules operate on line voltage, 120 V AC nominal, and are able to operate over the voltage range of 80 V AC to 135 V AC.

Provide transient voltage suppression rated at 1,500 W for 1 millisecond and fusing with a maximum rating of 2 A to minimize the effect and repair cost of an extreme over voltage situation or other failure mode.

Ensure the modules allow a reduction of the intensity of the light output in response to an input from the traffic signal controller. Ensure the minimum light output when dimmed is not less than 30% of the minimum maintained luminous intensity as defined in the applicable ITE Signal Head Module.

4. Operation

Supply LED Modules which start counting when the flashing “Don’t Walk” Indication starts and will countdown to “0” when the steady “Don’t Walk” signal turns on. Ensure that the countdown numbers remain continuously illuminated through the flashing don’t walk interval. Ensure that the unit maintains a consistent countdown during a short power failure (i.e. Traffic Controller does not restart). Ensure that if Traffic Controller restarts that the countdown timer display is turned off until one full pedestrian clearance Cycle is timed. Ensure that the unit will turn off the counter if the steady Don’t Walk Display starts while the countdown timer is displaying a number other than 00.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Ensure that LED traffic signal modules and LED Pedestrian modules are performance warranted to be in compliance with the latest ITE and CALTRANS minimum intensity Standards for LED traffic signal modules, measured at 120 V AC and 165 °F (74 °C), for a period of five (5) years.

Ensure that the manufacturer’s name, part number, date code, and electrical characteristics of the LED signal module is visible on the assembly, and that each LED signal module is identified for warranty purposes.

925.2.17 Blank-Out Signs

A. Requirements

Ensure that each sign provides a clearly visible and definable legend for 500 feet with ample safety factors.

Provide hardware to mount the sign on standard 1.5 inch (38 mm) pipe brackets or to mount directly to signal mast arms or span wire or as outlined in the Plans.

Ensure LED blank-out signs conform to the requirements of section 925.2.15 for LED modules and optical requirements.

Supply blank-out signs capable of displaying one message at a time in one direction.

1. Case

Use a case formed from aluminum extrusion F1-6-E and a special aluminum door frame angle.

For Alloy 6063-T5, ensure that the wall is at least 0.075 inches thick and the corners and joints are at least 0.080 inches (2 mm) thick.

Use filler arc for all welding. Ensure all hinges and fastening hardware, nuts, bolts, fasteners on the housing and internal components are stainless steel

Use a BR-type take-apart door hinge and draw bolt. Furnish one P-15 1.5 inch (38 mm) hub on the top surface.

Prime the entire case with zinc chromate, bake the inside with two coats of non-yellowing white, and paint the outside with two coats of highway yellow.

2. Electrical

Ensure that all blank-out signs are LED and conform to current ITE Standards. Supply all signs with the necessary mounting hardware to provide for mounting as shown on the Plans. Provide mounting for one way or two way configurations.

Obtain approval for messages and letter dimensions from the Engineer.

3. Sun Phantom Screen

Attach to each sign a heavy-duty aluminum louver-type sun phantom screen covering the entire sign face. Slant the louvers down enough to eliminate the sun glare without obstructing the view of the sign face.

4. Painting

Paint the signal surfaces, inside and out, with two coats of oven-baked enamel in addition to the primer coat. Paint the non-illuminated portions of the signal face black. Paint the housings, brackets, fittings, etc. highway yellow.

5. Lens

Use a fabricated, three-section Plexiglas lens clear face, with or without legend, which can accept a silk-screened legend on the first surface. Provide a thickness of at least 0.31 inches (8 mm).

6. Legend

Acceptable legends are as follows:

Text:

- NO LEFT TURN
- NO RIGHT TURN
- SIGNAL AHEAD
- NO TURNS

Symbols:

- NO LEFT TURN SYMBOL
- NO RIGHT TURN SYMBOL

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.18 Lane-Use Control Signal

A. Requirements

Ensure that all signals are LED and conform to current ITE Standards. Supply all signals with the necessary mounting hardware to provide for mounting as shown on the Plans. Provide mounting for one way or two way configurations.

1. General Requirements

a. Weight

Ensure that one-way units weigh not more than 50 pounds (23 kg) and two-way units weigh not more than 60 pounds (27 kg), regardless of messages.

b. Color

Ensure that the color of lane-use control signal indications is clearly visible for 0.25 mile (0.38 km) at all times under normal atmospheric conditions. Provide lane-use control signals with a visibility angle of a minimum of 60 degrees.

c. Housing

Ensure that the housing of each signal is polycarbonate or a one-piece corrosion resistant aluminum alloy die casting or equal and meets current related ASTM Specifications.

Ensure that all configurations are balanced to provide a plumb hanging unit. Ensure that all components are readily and easily accessible from the open door.

d. Housing door

Ensure that the housing door is one-piece corrosion resistant aluminum or polycarbonate and meets current related ASTM Specifications.

Provide two substantial door hinges with stainless steel hinge pins. Ensure hinges are on the left side of each section with a latch boss on the right side.

Provide stainless steel dual eye bolt latches or similar approved devices to securely close and latch the housing door. Equip the housing or door with a continuous molded neoprene gasket to make the interior of the unit dustproof and waterproof.

e. Wiring

Provide each signal housing with a complete terminal board. Ensure that one side of terminal strip accommodates socket leads and the other side accommodates field wires. Ensure that the terminal board provides totally separate wiring of each symbol.

Ensure each lamp is separately wired to a terminal block located in each housing. Provide each lamp holder socket with color-coded leads.

For combination symbols, color-code socket leads separately to distinguish between red "X", yellow "X" or downward arrow symbols. Provide leads that are No. 14 AWG type THW, 600 V AC, and fixture wire with 194 °F (90 °C) thermoplastic insulation.

f. Visors

Provide visors not less than 12 inches (300 mm) long for multiple unit and 7 inches (175 mm) long for single unit signals for each signal face.

Ensure that the visors are constructed of sheet aluminum or polycarbonate and encompass the top and sides of each section.

g. Painting

Paint all signal surfaces, inside and out, with two coats of oven baked enamel in addition to the primer coat. Paint the insides of the visors flat black.

The non-illuminated portions of the signal face black or dark gray and all housings, brackets and fittings highway yellow.

h. Hardware and fittings:

Supply all necessary fittings, pipe brackets, hangers, hubs, etc. for the type of mounting specified. Ensure all fittings are aluminum or galvanized coated to prevent rust and corrosion.

i. Sun -phantom screen

Provide each signal face with a screen, which substantially counteracts sun phantom effect.

2. Signal Display

Ensure that the symbols, which are on an opaque black or dark gray background, meet ITE requirements and are blacked out when not illuminated.

3. LED Optical System

a. Ensure that the LEDs supplied for the lane use control signal meet the Specifications for a type module as required in section 925.2.14. Ensure that each separate color indication in a sign face is illuminated by independent LEDs

b. Ensure that the green arrow indication does not utilize the same termination points as any "X" indication.

c. Ensure that total power required for any single indication does not exceed 250 W.

d. Ensure that all modules are contained behind a water tight signal face or lens assembly.

e. Ensure that the entire optical system is weatherproof and is not vulnerable to extremes in temperature or moisture.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.19 Pedestrian Push Button Station

A. Requirements

Ensure that Pedestrian push buttons are of tamperproof construction and consist of a direct push type button and single momentary contact switch in cast aluminum housing or Piezo driven solid state switch rated for a minimum of 50 V. The pushbutton cover shall also be of cast aluminum. The housing and cover shall be free of voids, pits, dents, molding sand excessive foundry grinding marks. Exterior surface shall be smooth and cosmetically acceptable, free of molding fins, cracks and other exterior blemishes.

Provide housing and cover with an alodine conversion coating so as to provide a proper base for paint adhesion. Finish the housing with baked enamel and paint the push button housing and Pedestrian heads highway yellow (unless otherwise specified by the Engineer).

The assembly shall be capable of being mounted to a flat or curved surface. Ensure the assembly includes the appropriate sign as shown in the Plan Details.

Ensure that any screws or bolts are stainless steel and vandal proof. Provide the unit with a 0.5 inch (13 mm) threaded opening with plug.

Ensure that the assembly is weatherproof and so constructed that when properly installed, it will be impossible to receive an electrical shock under any weather condition.

Ensure that Pedestrian Pushbuttons are integrated with a sign as shown in the standard details. Provide the sign size as indicated on the Plans. GDOT will allow an adapter of cast aluminum. GDOT will allow one of three options:

1. The use of a 9 inch (229 mm) by 15 inch (381 mm) cast aluminum plate adapter to upgrade existing push button station, 9 inch (229 mm) by 12 inch (305 mm).
2. Push button station assembly 9 inch (229 mm) by 15 inch (381 mm) sign w/round pushbutton adapter.
3. The use of a 9 inch (229 mm) by 15 inch (381 mm) cast aluminum plate adapter to upgrade existing push button station, 5 inch (127 mm) by 7 inch (178 mm).

Ensure that the Pedestrian Push Button sign adapter plate is, die-cast aluminum and separate, such that it is interchangeable.

Ensure that the Pedestrian Push Button sign adapter assembly be, die-cast aluminum and attached, prior to shipping.

The plate shall be finished with highway yellow baked enamel paint (unless otherwise specified by the Engineer).

Ensure the button assembly is configured to be a mechanical switch with ball and 2 inch (50 mm) mushroom plunger when not using Piezo driven switch.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01D for Materials Warranties.

925.2.20 Signal Head Back Plate

A. Requirements

Ensure that each back plate is designed to properly shield a traffic signal head from background distractions for better visibility.

Design the back plates to extend beyond the signal head a minimum of 4 inches (100 mm) and maximum of 6 inches (150 mm) on all sides and have all corners rounded with minimum 2 inch (50 mm) radii.

Construct the back plates from UV stabilized polycarbonate, ABS plastic, or aluminum material. Ensure that polycarbonate back plates are at least 0.15 inches (4 mm) thick; ABS back plates are at least 0.05 inches (1 mm) thick; aluminum back plates are at least 0.06 inches (1.5 mm) thick. All back plates shall be constructed with a finished color of flat black. Aluminum backplates should be finished with a durable, flat black colored powder coat.

Design the back plates with predrilled holes to provide for simple attachment to the specified brand, size and configuration of traffic signal head with all mounting hardware included.

Ensure that the back plates do not interfere with the signal mounting hardware. Ensure that the back plates include louvers.

Ensure back plates project a rectangular appearance at night by having a 2 inch (50mm) yellow TP IX retroreflective strip along the back plate perimeter.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.21 Signal Head Visors

A. Requirements

Typically, visors are one piece tunnel type and removable unless specified otherwise in the signal Plans.

Ensure that visors are polycarbonate and at least 9 inches (225 mm) deep for 12 inch (300 mm) heads. Special angle visors are full circle with the long side at least 18 inches (450 mm) deep. Ensure that visors provide a positive method of attaching to the door of the signal head that do not allow rotation. An acceptable method is to provide tabs that use stainless steel screws.

Unless otherwise specified by the Engineer, provide black signal head visors.

If special tools are required for visor adjustment, provide one set per project. Coordinate delivery of tools with District Signal Engineer.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.22 Signal Head Louvers

A. Requirements

Ensure that louvers (with the vanes oriented vertically) are directional with a 7-degree cutoff right of center. Rotating the louver 180 degrees will produce a 7-degree cutoff left of center.

Provide twelve-inch (300 mm) louvers with 5 vanes. Finish all louvered surfaces in flat black. Ensure that programmable louvers are directional with a 7-degree cutoff and that all louver surfaces have a flat black finish.

Ensure that the units can be installed and programmed in accordance with the manufacturer's instruction on visors that are recommended by the manufacturer.

Have the programmable louver display approved by the Engineer prior to placing the signal in stop and go operation.

If special tools are required for louver adjustment, provide one set per project. Coordinate delivery of tools with District Signal Engineer.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.23 Hardware For Mast Arm Mounting

A. Requirements

Ensure that signal heads are rigidly mounted to the mast arm. Provide mounting hardware that is in accordance with the following:

1. Adjustability

Ensure the mounting bracket is completely adjustable such that it allows; rotational adjustment about the bracket axis; vertical adjustment; rotational adjustment about the Mast Arm; and rotational adjustment from the vertical plane.

2. Attachment

Ensure the bracket is provided with air-craft grade galvanized steel cables with stainless steel fastening hardware and make a minimum of two wraps around to fasten the bracket to the arm. Ensure the bracket is easily adjustable to fit all sizes of round, elliptical or other shaped structure without special tools or equipment

3. Signal/Sign Accommodations

Ensure the bracket attaches to the signal or sign to assure maximum rigidity. When clamping the signal top and bottom, ensure a standard bracket accommodates all major signal manufacturers signal for 3, 4 and 5 section signal head configurations.

4. Wiring

All electrical wiring shall be completely concealed with the bracket. The vertical support shall be a gusseted "C" shaped extruded aluminum tube to accommodate the signal cable regardless of vertical positioning of the tube.

5. Materials

The upper and lower arms shall be cast 319 aluminum or equivalent. The lower arm shall be internally threaded to accommodate the threaded vertical support tube. Ensure the lower arm is furnished with plastic covers which slide and snap into place. Both arms shall have 72 tooth serrations cast into the arm to assure a positive lock with signal housing and shall be secured about their rotational axis with setscrews. Ensure the arms have a tri-bolt arrangement for attachment to the signal housing.

Ensure the vertical support is gusseted tube extruded from 6063-T6 aluminum. Ensure the tube includes a vinyl closure strip.

Ensure the mast arm clamp assembly is cast from 713 aluminum alloy or equivalent. Provide an assembly that allows for 360 degrees of rotation with no internal bracing obstructing the center opening. Provide two air-craft grade galvanized steel cables that have minimum tensile strength of 100,000 PSI (690 MPa).

Ensure that each bracket is complete with all necessary bolt, washers, gaskets and miscellaneous items to allow assembly of the signal to the bracket and the bracket to the mast arm. Ensure all aluminum parts have an Aldine finish. All non stainless steel parts shall have a yellow zinc di-chromate or galvanize finish.

This item will be approved upon submittal of catalog cuts. Refer to Standard Detail Drawings for additional information.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01D for Materials Warranties.

925.2.24 Hardware For Signal Head Pole Mounting

A. Requirements

Ensure this item consists of hardware adequate for the specific mounting. As a minimum provide the following hardware. 1 ½ inch pipe nipples of die cast aluminum that are a minimum of 12 inches (300 mm) and threaded with 1 ½ inch NPS threads on either end. On the upper and lower arm there shall be a serrated 72 tooth boss with set screw. Use a tri-stud adaptor to attach the signal housing to the mounting hardware. The upper arm shall have a neoprene gasket to provide weather tight fit. Hub plates for pole mounting shall be provided and they shall be appropriate for the particular mounting (round or flat). Hardware shall die cast aluminum alloy 380 or extruded. All die cast parts shall be cleaned in an alkaline cleaning compound Extruded parts shall have an alodine conversion coating to provide proper base for paint

adhesion. The assembly is to be painted federal yellow and baked in an oven. Ensure the assembly is provided with all required hardware. All other hardware shall be stainless steel.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Ensure that this item consists of hardware as shown in the standard details.

This item will be approved upon submittal of catalog cuts.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.25 Balance Adjuster

A. Requirements

Ensure this item consists of hardware that is cast from 316 Stainless Steel or 65-45-12 Ductile Iron or equivalent. Ensure castings are free of voids, pits, dents, molding sand and excessive grinding marks. Exterior surface shall be cosmetically acceptable and free of molding fins, cracks and other exterior blemishes. All hardware shall be supplied and be stainless steel or galvanized.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Ensure this item consists of hardware as shown in the Standard Details. This item will be approved upon submittal of catalog cuts.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.26 Hardware For Mounting Pedestrian Head

A. Requirements

Ensure this item meets the same criteria as 925.2.24.A and is in accordance with the Standard Details.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

Ensure this item consists of hardware as shown in the Standard Details. This item will be approved upon submittal of catalog cuts.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.27 Pedestal Pole

A. Requirements

The Pedestal poles support vehicle signal heads, pedestrian signal heads, IVDS and push button. Furnish Pedestal poles according to type and overall length.

Pedestal pole for vehicle display for one lane ramp metering operation shall be constructed to support one 12" (300 mm) signal head and one 8" (200 mm) signal head assembly as shown in the Plans.

Pedestal pole for ramp meter advance warning sign and flashing beacon shall be constructed to meet the sign manufacturer's structural requirements. Pedestal pole mounting adapter shall rigidly attach to the sign case's structural bracing. Cable entrance to the sign case shall be through the inside of the pole.

1. Ensure that all poles are made of one continuous piece of bare finish spun aluminum from top to base connection for the entire height of the pole.

The shaft, of appropriate shape, may or may not be uniformly tapered from butt to tip. A pole used to support only a traffic signal may be tapered.

2. Fabricate pole caps, when required, of cast material, and secure in place with set-screws.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.28 Pedestal Pole Base

A. Requirements

Ensure that all design radii are smooth and intact. Ensure that the exterior surface finish is smooth and cosmetically acceptable by being free of molding fins, cracks and other exterior blemishes.

Fabricate from new aluminum ingot. Do not use scrap materials.

Minimum requirements are as follows:

ALUMINUM ALLOY NO.	319
ELONGATION [% IN 2 IN. (50 mm)]	2.5
TENSILE STRENGTH, KSI (MPa)	34 (234)
BRINELL HARDNESS	85
YEILD STRENGTH, KSI (MPa)	19 (131)
SHEAR STRENGTH, KSI (MPa)	232 (1600)

1. Ensure this item consists of square cast aluminum with bare finish, and has a minimum weight of 21 pounds (9.5 kg). Thread the upper end to receive a 4 inch (100 mm) National Pipe Thread (NPT) pipe shaft.
2. Design the base so that it may be fastened to a foundation with four (4) 0.75 inch (19 mm) anchor bolts located 90 degrees apart on the bottom of the base. Provide slots in the bottom of the base 1.5 inch (38 mm) wide and 2.5 inches (63 mm) long measured along the circumference of the bolt circle, allowing a proper fit even if the bolts are placed slightly off center.
3. Design the base to accommodate bolt circles of a minimum of 12 inches (300 mm) through a maximum of 14.5 inches (363 mm) and anchor bolts with a minimum of 0.63 inches (16 mm) through 1 inch (25 mm) diameter.
4. Design the base with a removable plastic door. Ensure that the door opening is free of burrs and sharp edges and is no less than 8.5 inches (213 mm) square. Attach the door to the base using one socket button head screw to prevent unauthorized entry.
5. Ensure that the base meets or exceeds current AASHTO breakaway requirements. Provide test reports from an FHWA approved independent laboratory certifying that the base has been tested and meets all applicable requirements. In addition, supply a statement of certification from the FHWA stating such tests have been accepted and approved.
6. In order to prove structural soundness, provide a certification from a recognized independent structural laboratory certifying that the base will withstand a bending moment of 10,750 ft-lbs (14 575 N-m).
7. Ensure that the door is injection molded from ABS plastic to deter vandalism and theft, and has the following properties:

TEST	ASTM METHOD	VALUE
Tensile @ Yield [0.13 inches (3 mm)]	D638	6600 psi (45 500 kPa)
Flexural @ Yield	D790	11,000 psi (75 850 kPa)
Rockwell Hardness	D785	101 (R Scale)
Notched Izod	D256	5 ft-lb./in. (0.03 N-m/mm)

8. Ensure that the door exhibits the following properties:

- Has an edge thickness of 0.25 inches (6 mm) and a minimum thickness of 0.156 inches (4 mm)
 - Contains flame-retardant material, meeting or exceeding underwriters laboratories UL 94 test H.B
 - Gray aluminum tone in color, unless otherwise specified
 - Contains ultra-violet inhibitors and stabilizers for protection against UV degradation
 - Is injection molded with a smooth front finish
 - Has flat and straight surfaces without blisters, buckling or warping; have reinforcing ribs
 - Contains two (2) injection molded lugs on the bottom of the door with slots of the proper width and depth to fit the base door opening.
9. Supply the base with a set of four (4) anchor bolts, 0.75 inch (19 mm) diameter by 18 inches (450 mm) in length, material per ASTM A 572A 572M, Galvanized per ASTM A 153/A 153M. Supply (1) hex nut and (1) flat washer with each bolt.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

General Provisions 101 through 150.

925.2.29 Pedestal Pole Foundation Anchor Assembly

A. Requirements

Provide Foundation Anchor assembly that is 4 inches (100 mm) in diameter by 56 inches (1400 mm) with a single helical blade and a square fixed baseplate with combination underside holt-head retainer and dirt scrappers allowing flush- mount with the ground.

Provide Baseplate that is steel and conforms to ASTM A-36 material. Provide pipe with helical blade that is manufactured from ASTM A-53ERW Grade B Steel. Ensure 4 inch pipe has 2 inch (50 mm) by 3 inch (75mm) entrance hole 18 inches below the steel plate. Ensure the anchor assembly is hot dipped galvanized finish after fabrication and complies with ASTM A-123.

Ensure base plate has four slotted mounting holes to fit bolt circles from 7 ¾ inch (195mm) to 14 ¾ inch (375 mm). Provide 4 slotted mounting hole with a ¾ inch keyhole slot to permit bolt installation and replacement from the top surface without digging under the baseplate.

Ensure assembly is furnished with;

- Quantity of four ¾ inch(20 mm) -10NC x 3 inch(75 mm) square head galvanized ASTM 325 anchor bolts;
- Quantity of four ¾ inch(20 mm) plain flat galvanized washers;
- Quantity of four 3/16 inch(5 mm) thick galvanized plate washers;
- And, quantity of four ¾ inch (20 mm) galvanized hex nuts.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.30 Timber Poles

A. Requirements

Ensure that all timber poles meet the requirements of Section 861. Poles must be inspected and tested by the GDOT Office of Materials and Research and hammer stamped by the inspector.

Ensure that all poles have a brand or stamp 10 feet (3 m) from the butt that notes the type wood, date of manufacture, manufacturer, class and length.

Ensure that all timber poles that have guy attachments or support span wire or arms that suspend signal heads over the roadway or sidewalk are Class II.

Poles that support loop lead-in, messenger or communications cable that does not have guy attachments may be Class IV size.

Ensure that all poles meet the requirements in the table below unless otherwise noted on the traffic signal Plans or list of materials.

Minimum Circumference		
<u>Class</u>	<u>Nominal Length, ft (m)</u>	<u>At 6 feet (2.4 m) from butt, in. (mm)</u>
II	30 (9)	34.0 (850)
II	35 (10.5)	36.5 (913)
II	40 (12)	38.5 (963)
II	45 (13.5)	40.5 (1013)
II	50 (15)	42.0 (1050)
IV	30 (9)	29.5 (738)
IV	35 (10.5)	31.5 (788)
IV	40 (12)	33.5 (838)
IV	45 (13.5)	35.0 (875)

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.31 Traffic Signal Pull Box

A. Requirements

Ensure traffic signal pull boxes are matched assemblies consisting of boxes and covers from the same manufacturer.

For all pull boxes except Types 4 and 5, use pull boxes manufactured in a single unit for the full depth required in the size in an open bottom configuration. Do not use stacked pull boxes.

For pull boxes Types 4 and 5, use stacked pull boxes as shown in the Plans, where the top unit is open bottom and the bottom unit is closed bottom manufacture. In the bottom unit provide a drain hole.

Provide pull boxes that are non-metallic and gray or tan color.

Ensure that pull boxes meet all requirements of ANSI 77 2007 or current edition Tier 15. Provide compliance test documentation.

Provide a ¼-inch (6 mm) galvanized wire mesh between the gravel base and the open bottom box or closed bottom box drain hole for all pull box types.

Use Type 1 pull boxes [12 inches x 12 inches (300 mm x 300 mm)] for loop lead-ins. When loop lead-ins and splices and other cables are required, use Type 2 pull boxes [11 inches x 18 inches (275 mm x 450 mm)] or Type 3 pull boxes [17 inches x 30 inches (425 mm x 750 mm)]. Use Type 4, 4S, 5, 5S, 6 and 7 pull boxes for fiber optic cable. Furnish one-piece covers for all pull boxes except Types 5, 5S, and 7. Furnish two-piece covers for Types 5, 5S, and 7.

Furnish covers with a skid-resistant surface with a minimum coefficient of friction of 0.5 when tested in accordance with ASTM C1028.

Furnish covers with stainless steel hold-down bolts, minimum size 3/8-16.

Furnish covers with the logo “TRAFFIC SIGNAL” for pull box Types 1, 2 and 3, and with other pull box types when installed for traffic signal cabling at a traffic signal.

Unless otherwise shown in the Plans or installed for traffic signal cabling at a traffic signal, furnish covers with the logo “GDOT COMMUNICATIONS” for pull box Types 4, 4S, 5, 5S, 6 and 7.

Furnish pull box Types 4, 5, 6 and 7 with factory-installed cable racks and rack hooks.

Cable racks and rack hooks shall be hot-dipped galvanized steel.

Each cable rack rail shall be minimum 24 inches (600 mm) in length with rack hook mounting holes on the entire length. Install two racks on each of the pull box long side walls. For Type 4 and 5 pull boxes only, each cable rack rail may be comprised of two minimum 12 inch (300 mm) units installed on the stacked box side walls.

Mount cable racks to the side walls using minimum 3/8-16 stainless steel hardware.

Furnish a minimum of four rack hooks, minimum 6 inch length (150 mm), per pull box. Furnish an additional four rack hooks for each through cable stored in the pull box. Furnish an additional two rack hooks for each splice closure stored in the pull box.

Furnish Types 6 and 7 pull boxes with factory-installed non-metallic conduit terminators for Sch. 40 and SDR11 2-inch (53 mm) of the quantity and location as shown in the Plans, or for a different conduit size if shown in the Plans. Terminator bodies shall be manufactured from high-impact polystyrene or approved equivalent.

When joining conduits of dissimilar materials, furnish an airtight and watertight conduit adhesive intended for direct-contact underground use.

Refer to the Standard Detail Drawings and the Traffic Signal Design Manual for further information.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.32 Prefabricated Controller Cabinet Base

A. Requirements

Provide controller cabinet bases that are precast polymer concrete and grey in color. Ensure the prefabricated controller cabinet base has the correct bolt pattern for the cabinet(s) to be installed. Provide prefabricated controller cabinet bases with UNC inserts as shown on plans. UNC inserts shall be stainless steel and be designed for a minimum of 15 foot-pounds (20 N-m) of torque.

Ensure that prefabricated controller cabinet bases are designed to withstand wind loading of 125 mph (200 km/h) with the cabinets as shown in the Plans mounted. Ensure that prefabricated controller cabinet bases are designed for a minimum static vertical load of 5,000 pounds (2262 kg) over a 10 inch (254 mm) by 10 inch (254 mm) by 1 inch (25 mm) thick distribution plate and withstand a tested load of 7,500 pounds (3394 kg). Ensure that prefabricated controller cabinet bases are designed for a minimum lateral load of 1800 pounds (814 kg) over an 18 inch (457 mm) by 24 inch (610 mm) by 1 inch (25 mm) steel plate applied to the longest side and shall withstand a tested load of 2700 pounds (1222 kg). The prefabricated controller cabinet base shall withstand a 50 foot-pound impact administered with a 12-pound weight having a “C” tup without puncture or splitting, in accordance with ASTM D2444. The prefabricated controller cabinet base shall meet the requirement of ASTM D543 Section 7, Procedure 1. Provide a copy of all test reports from a certified lab along with the materials certification package.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.33 Loop Lead-In Cable

A. Requirements

Ensure that loop detector lead-in cable is No. 18 AWG, 3-pair shielded cable that meets IMSA specification #50-2.

Ensure that identification markings are stamped on the jacket.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.34 Loop Detector Wire

A. Requirements

Ensure that loop detector wire, meets IMSA specification 51- -3 and is 14 AWG.

For special applications loop detection wire that meets IMSA specification 51-7, 14 AWG, may be used as directed by the Engineer.

Stamp identification markings on the cable jacket.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.35 Aerial & Duct Signal Cable

A. Requirements

Ensure that aerial or duct (conduit) No. 14 AWG, stranded, 7-conductor, with black polyethylene (PE) jacket and 600 V AC rating meets IMSA specification #20-1. Use conductors that are straight, not twisted pairs.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.36 Self-Supporting Twisted Pair Aerial Signal Communications Cable

A. Requirements

Ensure that self-supporting, figure eight, aerial signal communications cable, No. 19 AWG, stranded 6-pair conductors is rated at 600 V AC and meet IMSA specification #20-4-1984.

Use conductors that are twisted pairs with copper tape shield under a black PE jacket. Ensure that messenger strand is 0.25 inch (6 mm), 7-strand and conforms to ASTM A 475 Siemens-Martin grade or better with a Class A coating.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.37 Underground Feeder Cable, Type UF

A. Requirements

Ensure that underground feeder cable, Type UF w/ground has two (2) conductors with pvc/nylon jacket and a minimum 600 V AC rating per UL #493. Two-conductor, No. 6 AWG wire may be used.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.38 Messenger & Guy Strand (Span Wire)

A. Requirements

Ensure that all messenger and guy strand (span wire) conforms to ASTM A 475 Extra High Strength grade or better with a Class A coating, 7-wire span wire.

Ensure ¼-inch (6 mm) Messenger & guy strand shall be used to support interconnect cable or as tether spans.

Messenger & guy strand 0.31 inch (7 mm) shall be used only where it is essential to match an existing 0.31 inch (7 mm) span wire that will not be replaced as part of a new installation.

Ensure all span wire for signal heads, blank out sign, optically programmed heads, lane control signs, standard, aerial or sidewalk guys uses a minimum Messenger & guy strand 0.38 inch (9 mm) as a minimum size.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.39 Power Disconnect Box

A. Requirements

Ensure that all power disconnect boxes are NEMA 3R 240 V AC, 60 Amp Phase 1(metal non-fused 2 pole). Ensure the disconnect box is supplied with a padlock keyed as per directions of District Signal Engineer. Provide power disconnect box that is not fused and does not have a circuit breaker. Supply with a service grounding kit.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.40 Cable Ties

A. Requirements

Ensure that all cable ties are nylon, ultraviolet resistant black and consist of the following as a minimum:

Nominal Length	8 inches (200 mm)
Width	0.30 inches (7 mm)
Tensile Strength	120 pounds (55 kg)

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.41 Lashing Rod

A. Requirements

Ensure that all lashing rods are sized in accordance with messenger and cable(s) diameters to be supported. Provide lashing rods that are of the same material as the messenger or guy strand.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.42 Stainless Steel Lashing Wire

A. Requirements

Provide lashing wire that is type 316 stainless steel with 0.045 inch (1 mm) diameter.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.43 Guy Guards

A. Requirements

Ensure that all guy guards are high impact resistant PVC with ultraviolet stabilizers added for retention of color. Ensure that insulators attach to the guy so that they cannot easily be removed. Use guy guards which are yellow unless otherwise directed.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.44 Guy Strain Insulators

A. Requirements

Ensure guy strain insulators are protected from the environment including the effects of voltage, ultraviolet rays, and acid rain by a fully bonded, electrically tack-free, and impenetrable silicone rubber sheath. Each insulator shall be UL proof tested, and permanently marked to show date of test.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.45 Universal Closure Kit

A. Requirements

Supply a Universal Signal Closure Kit to seal the signal head at either the top or bottom. Ensure that the kit will fit any manufacturer's signal head (top or bottom) without the use of special tools or modification.

1. Ensure that the gasket is 60-70 durometer neoprene.
2. Ensure that Closure Cap is injection molded ABS plastic. The plastic is to be loaded with UV stabilizers.
3. Ensure that Adapter Bar is made so that it will secure the closure cap and compensate for varying thickness of signal heads.
4. Provide two # 10 (9mm) screws to fit any manufacturer's signal head. Ensure that one screw is 0.75 inches (19 mm) in length and the second screw is 1 inch (25 mm) in length.
5. Pack each assembly in a clear plastic bag. Mark the bag with the manufacturer's name and part number. Include the Universal Signal Closure Kit in a package containing the span wire clamp and Tri-Stud wire entrance fitting.
6. Ensure that the Closure Cap is molded to closely match the color of the signal head (Federal Yellow). The adapter bar and screws are to be zinc plated steel.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.46 Cast Aluminum Span Wire Clamp

A. Requirements

Provide Span Wire Clamps that are cast from Aluminum Alloy 713 or equivalent, free of voids, pits, dents, molding sand and excessive foundry grinding marks. Ensure that all design radii are smooth and intact.

Provide an exterior surface finish that is smooth and cosmetically acceptable, free of molding fins, cracks and other exterior blemishes. Ensure that span wire clamps are fabricated from aluminum ingot with minimum requirements as follows:

ALUMINUM ALLOY No.	713
YIELD STRENGTH, ksi (MPa)	25 (172)
TENSILE STRENGTH, ksi (MPa)	35 (240)
BRINELL HARDNESS	75
ELONGATING [% in 2 inches (50 mm)] ³	

1. Ensure that the Span Wire Clamp can accommodate cables 0.25 inch (6 mm) to 0.63 inch (16 mm) diameter.
2. Ensure that the weight is less than 1.75 pounds (0.8 kg) with hardware.
3. Ensure that the Span Wire Clamp have a minimum overall length of 7 inches (175 mm).
4. Ensure that the Span Wire Clamp have a centerline dimension from cable to clevis pin of 2 inches (50 mm) [+/- 0.5 inches (13 mm)].
5. Ensure that the Span Wire Clamp have a cast aluminum cable bar to protect the cable when tightening the U-bolts.
6. Ensure that the Span Wire Clamp have a mounting opening of 0.75 inches (19 mm) [+/- 0.03 inches (0.8 mm)].
7. Ensure that the Span Wire Clamp have 0.5 inch (13 mm) - 13 NPT U-bolts with 0.5 inch (13 mm) lock washers and nuts.
8. Ensure that the clevis pin are 0.63 inch (16 mm) diameter with a length of 2.25 inches (56 mm) and secured with a hump back stainless steel cotter pin.
9. Ensure that the Clamp and Cable Bar have an Alodine 1200 conversion coating to help resist oxidation.
10. Ensure that the Clevis Pin and hardware are galvanized per ASTM 123/A 123M or stainless steel.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.47 Cast Aluminum Tri-Stud Span Wire Entrance Fitting

A. Requirements

Ensure that the Tri-Stud Span Wire Entrance Fittings are cast from Aluminum Alloy 713 or equivalent, free of voids, pits, dents, molding sand and excessive foundry grinding marks.

Ensure that the all design radii are smooth and intact. Ensure that the exterior surface finish is smooth and cosmetically acceptable, free of molding fin, cracks and other exterior blemishes.

Ensure that the material is fabricated from aluminum ingot with minimum requirements as follows:

ALUMINUM ALLOY No.	713
YIELD STRENGTH, ksi (MPa)	25 (172)
TENSILE STRENGTH, ksi (MPa)	35 (240)
BRINELL HARDNESS	75
ELONGATION [% in 2 inches (50 mm)]	3

1. Ensure that the Tri-Stud Span Wire Entrance fitting has a mounting support at the top of the wire entrance 0.69 inches (17 mm) thick [+/- 0.07 inches (1.5 mm)].
2. Ensure that the Tri-Stud Span Wire Entrance fitting weight is not less than 1.75 pounds (0.8 kg) with hardware.
3. Ensure that the mounting support has at least six (6) clevis openings for adjustment with suspension bracing between every two (2) openings.
4. Ensure that the Tri-Stud Span Wire Entrance has a minimum of 0.5 inch (13 mm) diameter throughout for wire access and that wire access is free of burrs and casting webs.
5. Ensure that the Wire Entrance opening is recessed and has a neoprene grommet with sealed membrane sections.

6. Ensure that the signal head attachment end is serrated and has a minimum of 3-signal head centering bosses extending 0.19 inches (5 mm) from the serrations.
7. Ensure that the serrations have a 72-tooth design to match the signal head.
8. Ensure that three (3) stainless steel studs are cast into the wire entrance fitting. Ensure that the studs are 0.31 inches (7 mm) and extend 1.5 inches (38 mm) [+/- 0.13 inches (4 mm)] beyond the serrations. Provide each Tri-Stud span wire entrance fitting with a Tri-Stud hardware kit.
9. Ensure that the Tri-Stud Span Wire Entrance Fitting has an alodine conversion coating to provide a proper base for paint adhesion. Ensure that the assembly matches display housing (per plans) and baked in a drying oven after painting.
10. Ensure that the all Hardware is galvanized or stainless steel.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.48 Bull Rings

A. Requirements

Provide bull rings that are galvanized weldless steel 0.63 inch (16 mm) diameter. Submit catalog cuts for approval.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.49 Ramp Meter Enforcement Device

A. Requirements

For each metered lane, provide one ramp meter enforcement device mounted on the back of one signal per lane and wired directly to the red signal display, (Refer to 647.3.05.L). This installation shall include a Red 44 LED Array (allnGaP), Pixel housing, 6061 aluminum powder coated swivel bracket, 2 inch lens, with an aluminum hood. Mounted and adjusted as per the Plans.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.50 Vinyl Electrical Tape

A. Requirements

Ensure electrical tape used is flame retardant, cold and weather resistant. Provide tape that is rated for 600 volts and for use between 0 F (-18 C) and 176 F (80 C).

Ensure tape is 0.0085 inches (0.2 mm) thick and meets the requirements of UL 510 and Mil-I-24391. Provide tape that remains flexible with abrasion resistance.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

General Provisions 101 through 150.

D. Materials Warranty

Refer to Subsection 925.2.01.D for Materials Warranties.

925.2.51 Rectangular Rapid Flashing Beacon Assembly

A. Requirements

Provide Rectangular Rapid Flashing Beacon Assemblies in the quantities and locations indicated in the Plans. Provide all equipment, materials, and work in accordance with all manufacturers’ recommendations, including but not limited to all mounting, wiring and cabling, power supply, surge suppression, and communications equipment and materials.

Ensure all provisions of the MUTCD applicable to Warning Beacons are met except as otherwise provided in this Specification.

RRFB assembly shall consist of the following components: beacons, mounting pole and foundation, wireless subsystem, solar panel subsystem.

1. Rectangular Rapid Flashing Beacon Assembly

Ensure that the individual components and assemblies of the Rectangular Rapid Flashing Beacon Assembly conform to the requirements specified herein.

Ensure that all equipment, materials, components and assemblies of the Rectangular Rapid Flashing Beacon Assembly conform to manufacturer’s requirements and recommendations.

Construct the system with all electronic components of solid-state design and modular construction and designed for the environment in which they will be installed.

Deliver the Rectangular Rapid Flashing Beacon Assembly with connectors, fasteners, etc. preventing reversed assembly or installation or where possible malfunction or personnel hazards might occur.

Deliver and install the Rectangular Rapid Flashing Beacon Assembly with any other equipment or components needed for safe and reliable operation.

Ensure the Rectangular Rapid Flashing Beacon Assembly consists of but is not limited to the following components and materials:

- Rectangular Rapid Flashing Beacon Assembly
- Solar cell/battery power source
- Signs
- Wireless subsystem
- Push button activation system
- Mounting Hardware
- Configuration and data collection software
- Installation and testing

Ensure Rectangular Rapid Flashing Beacon Assembly meets the performance requirements listed below:

a. Beacon Dimensions and Placement in Sign Assembly

Contains two rectangular-shaped yellow indications, each with an LED-array based light source. Each indication is a minimum of 5 inches wide by 2 inches high. LEDs face oncoming traffic when installed.

The longer dimensions of the Rectangular Rapid Flashing Beacon indications are aligned horizontally.

The minimum space between the two indications is 7 inches measured from inside edge of one indication to inside edge of the other indication.

The outside edges of Rectangular Rapid Flashing Beacon indications, including any housing, do not project beyond the edges of the S1-1 sign.

The Rectangular Rapid Flashing Beacon indications are located between the bottom of the crosswalk warning (S1-1) sign and the top of the supplemental downward diagonal arrow (W16-7p) sign.

b. Beacon Flashing Requirements

The beacon shall follow the following wig-wag and strobe (WW+S) display pattern:

- A flash cycle length of 800 milliseconds, which results in 75 flash cycles per minute. The 800-millisecond flash cycle shall have the following sequence:
 - **The left side beacon is on for 50 milliseconds**
Both beacons are off for 50 milliseconds
 - **The right side beacon is on for 50 milliseconds**
Both beacons are off for 50 milliseconds
 - **The left side beacon is on for 50 milliseconds**
Both beacons are off for 50 milliseconds
 - **The right side beacon is on for 50 milliseconds**
Both beacons are off for 50 milliseconds
 - **Both beacons are on for 50 milliseconds**
Both beacons are off for 50 milliseconds
 - **Both beacons are on for 50 milliseconds**
Both beacons are off for 250 milliseconds

The flash rate of each individual yellow indication, as applied over the full on-off sequence of a flashing period of the indication, is not between 5 and 30 flashes per second, to avoid frequencies that might cause seizures.

The light intensity of the yellow indications meets minimum specifications of Society of Automotive Engineers (SAE) standard J595 Class I (Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles) dated January 2005.

c. Beacon Operation

The Rectangular Rapid Flashing Beacon stays normally dark and initiates operation only when actuated by a pedestrian.

The Rectangular Rapid Flashing Beacon ceases operation at a predetermined time after pedestrian actuation and by passive detection, after the pedestrian clears the crosswalk.

All Rectangular Rapid Flashing Beacons associated with a given crosswalk (including those with an advance crossing sign, if used) simultaneously commence operation of their alternating rapid flashing indications when activated and cease operation simultaneously.

Uses pedestrian pushbuttons to actuate the Rectangular Rapid Flashing Beacons.

Includes a pedestrian instruction sign with the legend PUSH BUTTON TO TURN ON WARNING LIGHTS mounted adjacent to or integral with each pedestrian pushbutton.

The duration of a predetermined period of operation of the Rectangular Rapid Flashing Beacons following each actuation is based on the MUTCD procedures for timing of pedestrian clearance times for pedestrian signals.

Includes a small light directed at and visible to pedestrians in the crosswalk installed integral to the Rectangular Rapid Flashing Beacon or push button to give confirmation that the Rectangular Rapid Flashing Beacon is in operation.

Powered by solar cells and batteries with automatic battery charging and power control.
Uses wireless communication to avoid trenching.

The Rectangular Rapid Flashing Beacon is visible a minimum distance of 1000 feet during daytime and nighttime.

d. Wireless Subsystem

Frequency in the 900 MHz FHSS or 2.4 GHz range.
Range: minimum 500'.

e. Solar Panel Subsystem and Batteries

Solar Panel Output: min 20 watt panel or as required by the manufacturer.

Batteries: Batteries shall be sealed and maintenance free with a minimum lifespan of 3 years. Battery type shall be Sealed Valve Regulated Lead Acid Batteries or 12V, 20-40AH Sealed Gel or approved equivalent.

Cabinet (if required): Shall be pole mounted NEMA 4 rated fiberglass cabinet with locking clasps or powder coated aluminum with tamper prove hinged door or approved equivalent.

Solar Panel Mount: pole mount with 60° angle bracket or manufacturer recommended specifications.

2. Mounting Pole and Foundation

Provide a breakaway mounting pole and foundation designed to support the Rectangular Rapid Flashing Beacon and the associated solar panel, batteries and all equipment required to supply a complete Rectangular Rapid Flashing Beacon.

Determine pole foundation dimensions based on the local conditions at the locations indicated in the Plans. Ensure the pole foundation provides a safe and secure mounting of the solar powered Rectangular Rapid Flashing Beacon Assembly.

3. Pedestrian Push Button

ADA Pedestrian push buttons are located perpendicular to signal indication and as required by field conditions. ADA Pedestrian push buttons are located 3.5' (1.05m) above sidewalk or ground level.

Provide the Engineer with plans and drawings illustrating the mounting structure and the installed Rectangular Rapid Flashing Beacon.

B. Fabrication

General Provisions 101 through 150

C. Acceptance

General Provisions 101 through 150

D. Materials Warranty

1. Warranty

Provide to the District Engineer or maintaining agency all manufacturers' warranties and guarantees for all Rectangular Rapid Flashing Beacon Assembly equipment and materials.

Ensure that the warranties and guarantees are consistent with those provided as customary trade practices, or as otherwise specified in the Plan, Standards Specifications, Supplemental Specifications or Special Provisions.

Ensure, and state, that the manufacturer's and supplier's warranties and guarantees are transferrable to the agency or user that is responsible for traffic signal maintenance. And said warranties and guarantees are continuous throughout their duration.

Ensure equipment provided under this specification shall be warranted by the manufacturer to be free from defects in materials and workmanship for a minimum of two years from date of receipt or one year from date of acceptance of installation. The exception is the other materials stated in this specification which have longer warranty durations.

Ensure that the manufacturer will repair any faulty equipment during this period at no charge to the Department for parts, labor or shipping to and from factory.

2. Support

Provide phone consultations as needed during the warranty period at no cost for any operating and maintenance questions or problems.

E. Measurement

1. Equipment

- Rectangular Rapid Flashing Beacon Assembly

Rectangular Rapid Flashing Beacon Assemblies are measured per each Rectangular Rapid Flashing Beacon Assembly completed and accepted.

2. Payment

- Rectangular Rapid Flashing Beacon Assembly

Rectangular Rapid Flashing Beacon Assemblies are paid for at the Contract Unit Price per each. Payment is full compensation for furnishing and installing the Rectangular Rapid Flashing Beacon Assembly.

Payment for Rectangular Rapid Flashing Beacon Assembly is made under:

Item No. 925	Rectangular Rapid Flashing Beacon Assembly	Per Each
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925.2.52 Uninterruptible Power System

A. Requirements

This specification establishes minimum requirements for an Uninterruptible Power System/Power Conditioner for use with traffic control equipment. The UPS shall include, but not be limited to the following: Electronics module, Integrated Power Interface Module and Battery System.

1. UPS assemblies shall be designed for installation in a roadside enclosure to provide battery backup functionality for traffic control systems, including traffic signal and intelligent transportation system (ITS) devices.
2. The UPS shall include batteries provided by the UPS manufacturer or in accordance with the manufacturer's requirements and GDOT QPL.
3. Loss of utility power, transfer from utility power, and transfer back to utility power must not interfere with normal operation of connected equipment.
4. UPS assemblies used to provide backup power in an ITS cabinet must provide a minimum of 350 watts (at 120VAC) of continuous backup power for a minimum of two hours. UPS assemblies used to provide backup power in a traffic signal controller cabinet must provide a minimum 400 watts (at 120VAC) of continuous power for a minimum of 6.5 hours.

5. The UPS shall regulate frequency to 60 Hz, plus or minus 0.5 Hz, while the UPS is supplying power.
6. All equipment used to keep the intersection signalized must be backed up and protected by the UPS.
7. Double-conversion UPS must be capable of simultaneously producing fully regenerated and regulated, conditioned, True Sine Wave power and hot standby AC output, and have a minimum operating efficiency of 90%.
8. The UPS shall be designed for outdoor applications in accordance with CALTRANS TEES, UL 1778 and applicable NEMA standards.

The UPS electronics shall consist of:

- Fully software defined, digital signal processor, Power Factor Corrected true online double conversion UPC/UPS (Universal Power Conditioner and Uninterruptable Power Supply)
- 3 stage, temperature compensated battery charger
- Local and remote control of UPS functions
- Local and remote monitoring features

B. Operation

- 1) The unit shall be capable of on-site programming, monitoring, and operation without the use of an external device. (i.e. – portable PC)
- 2) The UPC/UPS shall provide continuous, fully conditioned and regulated sinusoidal (AC) power to critical devices in the traffic control cabinet.
- 3) The UPC/UPS shall provide a minimum of three sets of normally open (NO) and normally closed (NC) single pole, double throw (SPDT) dry relay contact closures, available on a panel mounted terminal block, rated at a minimum 120V/1A, and labeled so as to identify each. Typical configurations are as follows:
 2. Energize on switch to battery power
 3. Energize on low battery life remaining (i.e. 40%)
 4. Run timer (i.e. Contact closure after 2 hours of operation)
- 4) Contact closures shall be annunciated on the front panel by a visual indication, such as a discreet LED or part of a LCD screen.
- 5) Operating temperature for the UPC/UPS and the batteries shall be -40°C to +74°C.
- 6) Upon loss of utility power the UPS shall insert battery power into the system and return to utility power upon restoration of service.
- 7) In the event of UPS failure or battery depletion, connected equipment must be energized automatically upon restoration of utility power.
- 8) The battery charging system shall be temperature-compensated and compensate over a range of 2.5 – 4.0 mV/°C per cell. The sensor shall be delivered with 10 feet of wire.
- 9) Batteries shall not be recharged when the battery temperature exceeds +50°C + -3°C.
- 10) UPC/UPS system shall be 19" rack mountable and compatible with ITS Model 340 cabinets and companion cabinets mounted adjacent and/or attached to an existing traffic control cabinet. An auxiliary generator plug assembly shall be accessible on the exterior of the cabinet. (Battery cabinet spec provided as a special provision)
- 11) UPS shall be equipped to prevent malfunction feedback to the cabinet or utility service.
- 12) Recharge time for the battery, from protective low cut-off to 80% or more of full capacity shall not exceed twenty (20) hours.
- 13) The Bypass switch shall enable removal and replacement of the UPC/UPS without shutting down the traffic control system. The UPC/UPS shall be capable of starting when no utility line service (AC) is available.
- 14) The UPC/UPS shall not interfere with the existing traffic control components.
- 15) The UPC/UPS shall deliver 120 VAC output, + or – 3% with an AC input between 75 and 155 VAC without discharging the batteries.
- 16) The UPC/UPS shall support a generator input without using the batteries.
- 17) The unit shall have maximum dimensions of 19 inches in width, 13 inches in depth and 6 inches in height. The unit shall have a maximum weight of 35 pounds.
- 18) The unit shall provide the following electrical characteristics:
 1. Input
 - Nominal voltage, 120 VAC, single phase
 - Frequency, 45 to 65 Hz
 - Maximum current draw, 17 amps
 - Protection breaker, 20 Amps
 2. Output

- Nominal voltage, 120 VAC, single phase
- Power rating: minimum – 1250 VA, 875 Watts
- Voltage regulation + or – 2% for 100% step load change and from high battery to low battery condition
- Frequency 50 or 60 Hz (+ or – .25, software selectable)
- Configuration keyed connectors and duplex receptacle
- Overload capability 110% for 10 seconds, 200% for 50 milliseconds

C. Displays, Controls and Diagnostics

1. The UPC/UPS shall include a display and/or meter to indicate current battery charge status and conditions.
2. Voltmeter standard “banana jacks” (+) and (-) mounted on the front panel to read the exact battery voltage drop at the inverter input.
3. Front panel indicated 0 to 100% battery capacity.
4. Built in TVSS (surge suppression) compliant with IEEE/ANSI C.62.4.
5. Integral system to prevent destructive battery discharge and overcharge.
6. Batteries shall be serviceable from the cabinet and shelf system without the need for specialized tools and/or compartment disassembly.
7. An event counter and total hours run time accessible from the front panel display, resettable by front panel command entry.
8. Manufacturer shall include a set of equipment lists, operation and maintenance manuals, battery data sheets, board level schematic and wiring diagrams of the system.
9. The UPC/UPS system shall provide front panel controls for: Power ON, Cold Start, Alarm Silence, Battery Test, Bypass Breaker, DC/Battery Breaker, Battery Test Points, Auxiliary Temperature Connector and Programming Keypad. The UPC/UPS system shall provide a standard EIA 232 interface using a DB 9 connector for remote monitoring and control of system functions. Remote 75 and 155 VAC without discharging the batteries.
10. The UPC/UPS system shall provide a standard EIA 232 interface using a DB 9 connector for remote monitoring and control of system functions. Remote monitoring and full command and control software and a serial connecting cable shall be provided.
11. A NIC (Network Interface Card) shall be provided and the UPC/UPS firmware shall support SNMP protocol and have standard UPS MIBs onboard. The system shall be capable sending SNMP messages that can be trapped with network monitoring tools such as Orion Network Performance Monitor. Remote monitoring and control shall be accessible via a WEB browser interface.

D. Battery System

1. Individual batteries shall be:
 - a. 12 volt rating.
 - b. Group 24 maximum case size.
2. Battery string shall consist of a minimum of 6 batteries with a cumulative minimum rated capacity of 240 amp-hours.
3. Batteries shall be deep cycle, sealed prismatic lead-calcium based.
4. AGM/SVRLA (Absorbed Glass Mat/Valve Regulated Lead Acid)
5. Batteries shall provide a connection system that shields the terminal from exposure and accidental shorting.
6. Batteries shall be certified to operate over a temperature range of -40°C to +74°C.
7. Batteries shall be provided with appropriate interconnect wiring and corrosion resistant mounting trays and/or brackets appropriate for the cabinet into which they will be installed.
8. Batteries shall indicate maximum recharge data and recharge cycles.
9. Labels shall be included identifying the date of manufacture. Batteries delivered with a manufacture date older than 6 months will be rejected.
10. Battery Harness
 - a. Battery interconnect wiring shall be via two-part modular harness. The cables shall be protected with abrasion resistant nylon sheathing. The interconnect cables shall connect to the base module via a quick release connector. The connector shall have interlocking pins to prevent battery operation if the batteries are not connected. Battery interconnect harness wiring shall be UL style 1015 CSA TEW or Welded Style Cable or equivalent, or proper wire gauge with respect to design current and sufficient strand count for flexibility.
 - b. Battery construction shall include heavy duty, inter-cell connection for low impedance between cells.

E. Acceptance

Each UPC/UPS shall be manufactured in accordance with a manufacturer Quality Assurance program (QA). The QA program shall include Production QA that include statistically controlled routine tests to ensure minimum performance levels of UPC/UPS units built to meet this specification and a documented process of how problems are to be resolved. The manufacturer, or an independent testing lab hired by the manufacturer, shall perform Design Quality Testing when any design change results in any alteration to the circuit configuration or performance characteristics.

F. Materials Warranty

Manufacturers shall provide a two (2) year factory repair warranty for parts and labor on the UPC/UPS from date of acceptance by the Department. Batteries shall be warranted for full replacement for the first year and 50% discount off the original purchase price for the second year from date of purchase.

Section 927 –Luminaires, LED

927.1 General Description

This section includes the requirements for LED (Light Emitting Diode) luminaires.

927.1.01 Related References

A. Standard Specifications

General Provisions 101 through 150.

Section 680 – Highway Lighting

ANSI/IES Types (specified on Plans)

927.2 Materials

Use luminaires that are complete, including driver, LED, surge protection device (SPD), and associated hardware and wiring.

927.2.01 Luminaires

A. Requirements

Ensure that LED luminaires meet the following requirements:

- Certified by Nationally Recognized Testing Laboratories (NRTL) as defined by the U.S. Department of Labor. The testing laboratory must be listed by OSHA in its scope of recognition for the applicable tests being conducted as required by this specification. A list of recognized testing labs for products sold in the United States may be found on the U.S. Department of Labor's web site:
- Certification mark by a NRTL as being in compliance with UL 1598 and suitable for use in wet locations.
- Ensure LED light source(s) and driver(s) are RoHS compliant.
- International Electrotechnical Commission (IEC) 529 Ingress Protection (IP) rating of IP66 or greater is used for all luminaires.
- Comply with Electro Magnetic Interference (EMI) requirements as defined by FCC 47 Sub Part 15; CISPR15, CISPR22 Class A (120Vmin).
- Perform testing according to the Illuminating Engineering Society of North America (IESNA) LM-79 and LM-80
 - a. Supply testing and data in compliance with LM-79 from a National Institute of Standards and Technology (NIST) National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory.
- Listed and labeled in accordance with the U.S. Department of Energy Lighting Facts Program:<http://www.lightingfacts.com/default.aspx?cp=content/products>

B. Housing

Ensure the housing for LED luminaires meet the following requirements:

- Provide aluminum housing.
 - a. If die cast aluminum housing is provided, use Aluminum alloy that is A360 or A380 compliant.

- Anodized and/or painted or powder coated with a minimum thickness of 2.0 mil to increase corrosion resistance. Finish color to be gray unless otherwise specified on plans. Luminaire finish to be tested to withstand a 2000-hour salt spray test in accordance with ASTM B117.
- All hardware on the exterior of the housing including cover and latch to be stainless steel, zinc or steel with zinc alloy electroplate and chromate top coat.
- Ensure roadway luminaires are easy to open when properly mounted or when sitting on its top side when placed on the ground without the use of tools. Ensure underpass luminaires are vandal-proof.
- Have readily accessible internal parts.
- Provisions for a slip fitter type mounting on nominal 2" (2-3/8" OD) pipe brackets.
- Slip fitter mount is to allow a minimum 4 inches of the pole bracket to be inserted in the luminaire mounting assembly.
 - a. The mounting assembly is to permit any necessary adjustment to orient the luminaire with the roadway for proper light distribution.
- Ensure the total weight of luminaire(s) and accessories do not exceed the load capacity of the pole and arm.
- Compliant with American National Standard (ANSI) IEEE C136.31 Roadway Lighting Equipment - Luminaire Vibration for both normal applications and bridge and overpass applications.
- Provide luminaires with a flat area on the top of the housing to allow a level to be used for proper orientation of the Luminaire, or supply luminaires with an integral bubble level.
- Provide luminaires that are capable of accommodating a photo-electric control receptacle (PECR). When used (see plans for applicability) the PECR to be rotatable up to 359 degrees. Housing is to provide 360 degree stop to prevent the internal twisting of PECR wire assemblies resulting in potential electrical short.
- Designed to allow water shedding.
- Passive cooling method to be employed with no energized or moving components to manage thermal output of LED light engine and power supply.

C. Electrical Requirements

Ensure that LED luminaires meet the following electrical requirements:

- Electronic components capable of fully operating in a temperature range -40°C to +50°C (-40° F to 122°F).
- Have an integral power supply.
- Equipped with a power supply that operates within the voltage range specified in the plans.
- Equipped with a power supply that has a power factor of .90 or greater at full load.
- Equipped with a power supply that has total harmonic distortion of 20% or less at full load.
- Provide lumen output sufficient to meet the lighting criteria as specified in the Plans.
- Equipped with an isolated power supply output.
- Equipped with a power supply that has overheat protection.
- Equipped with a power supply that is self-limited short circuit protected and over load protected.
- Equipped with a power supply that is terminated with quick disconnect wire harnesses for easy maintenance. Wire nut termination is not acceptable.
- Equipped with a terminal block for terminating pole wiring to the luminaire. The terminal block is to be a 3 station, tunnel lug terminal board that accommodates up to #8 AWG wire.

- Have a life rating on all electrical components of 100,000 hours or greater when operating at a continuous 25°C ambient.
- Electrical components protected per ANSI/IEEE standard C62.45; test waveform is to be as described in ANSI/IEEE C62.41.2; and type Category C environments as defined in ANSI/IEEE C62.41.1
- Equipped with a UL-labeled, 3-wire surge protective device (SPD) that provides common and differential mode protection and an inductive filter circuit that reduces the amount of energy passed through to the electronics during a surge event. SPD to be thermally fused and have failure mode such that luminaire is off if SPD fails. SPD to provide IEEE/ANSI C62.41 Category C (10kV/5kA) level of protection for the entire luminaire.

D. LED Performance Requirements

Ensure that LED luminaires meet the following performance requirements:

- Fully operate in a temperature range -40°C to +50°C (-40° F to 122°F).
- No more than a 15% reduction in LED's lumen output due to the operating temperature of the luminaire, compared to the LED's lumen output when it is operating at 25°C.
- Deliver an average 80% of initial delivered lumens after 100,000 hours of operation when operated at 25°C.
- A minimum rated life of 70,000 hours when operated at 25° C (77° F).
- Luminaire efficacy of a minimum of 70 lumens/watt.
- Meet the Chromaticity requirements as follows:
 - a. The colors conform to the following color regions based on the 1931 CIE chromaticity diagram.
 - 1) Color Temperature: 4000K (3710-4260K)
 - 2) Color Rendering Index (CRI): greater than or equal to 60
 - b. Intensity and Chromaticity as stated above must be confirmed by an independent test lab.

E. Optical Requirements

Ensure that LED luminaires meet the following optical requirements:

- Luminaire housing is to be a completely sealed optical system with a (IEC) (IP) rating of 66 or greater.
- The light distribution pattern at the road surface is to have an evenly dispersed appearance.
- Provide the IES pattern as identified on the Plans.

F. Fabrication

General Provisions 101 through 150.

G. Acceptance

1. General Provisions 101 through 150.
2. Each Luminaire to be evaluated by the Department for proper operation under a 30 day burn-in period after installation. If any failures are found in the first 30 days after installation, the Luminaire is to be replaced at no cost to the Department and be evaluated for another 30 days from the time of its installation. The system is acceptable when all luminaires pass the 30 day burn-in period with no failures.

H. Materials Warranty

1. General Provisions 101 through 150.
2. The entire Luminaire assembly including material, finish, workmanship, power supply, LED modules and lumen maintenance is to have a minimum of five (5) year warranty from the date of installation. On-site replacement includes transportation, removal and installation of new products. Finish warranty includes deterioration such as blistering, cracking, peeling, chalking or fading.

Section 936—Closed Circuit Television (CCTV)

Delete Section 936 and substitute the following:

936.1 General Description

This work includes furnishing and installing closed circuit television (CCTV) systems, any specified type, which is a CCTV video surveillance camera, including but not limited to color CCTV cameras, lenses, housing, pan/tilt drive, camera system assembly, cabling, mounting hardware, interface panel, camera control receiver, and cabinet wiring. This CCTV system includes both fixed and PTZ cameras as called for in the plans, provides operator control, and video imaging to the Department's NaviGator Intelligent Transportation System (ITS), or other camera operating software indicated on the plans or in the contract documents.

Provide all equipment, materials, and work in accordance with all manufacturers' recommendations, including but not limited to all mounting, wiring and cabling, power supply, surge suppression, and communications equipment and materials. Use only equipment and components that meet the requirements of these minimum specifications and are listed on the Department's Qualified Products List (QPL).

936.1.01 Definitions

CCTV System, Type B – The Type B PTZ Dome CCTV System uses a self-contained camera system assembly with an analog NTSC video output and RS-232 or RS-485 serial data control interface. This camera shall be compatible with the legacy NaviGator System and should be used for additions/replacement within existing system segments.

CCTV Camera Type C – The Internet Protocol (IP) PTZ Dome Camera System (IP) camera uses a built in encoder to provide H.264 or Moving Picture Experts Group's MPEG4 part 10 video compression technology in accordance with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 14496-10:2014 standard. This camera shall be compatible with the legacy NaviGator System. . Ensure that the camera is capable of unicast and multicast operation. Ensure the encoded video can be transmitted utilizing programmable bit rates. Ensure the camera supports, at a minimum, fixed bit rate mode. Ensure that the camera supports the National Transportation Communications for ITS Protocol (NTCIP) 1205 v1.08 Amendment 1(2014). Ensure that the camera is capable of communication with other devices using transmission control protocol (TCP)/IP. Ensure that the camera supports the communication links shown in the Plans. The camera must be capable of remote firmware upgrade via the communication interface.

CCTV Camera Type D – The Internet Protocol (IP) Fixed Camera System uses a built in encoder to provide H.264 or Moving Picture Experts Group's MPEG4 part 10 video compression technology in accordance with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 14496-10:2009 standard and is for locations where fixed views are desired. Ensure that the camera is capable of unicast and multicast operation. Ensure the encoded video can be transmitted utilizing programmable bit rates. Ensure the camera supports, at a minimum, fixed bit rate mode. Ensure that the camera supports the National Transportation Communications for ITS Protocol (NTCIP) 1205 v1.08 Amendment 1 (2104). Ensure that the camera is capable of communication with other devices using transmission control protocol (TCP)/IP. Ensure that the camera supports the communication links shown in the Plans. The camera must be capable of remote firmware upgrade via the communication interface.

CCTV Camera Type H – The Internet Protocol (IP) High Definition Camera System uses a built in encoder to provide H.264 or Moving Picture Experts Group's MPEG4 part 10 video compression technology in accordance with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 14496-10:2009 standard and with a minimum pixel resolution of 1920 x 1080 and an aspect ratio of 16:9 which is able to support simultaneous broadcast of lower resolutions. It must be compatible with the NaviGator System and provides enhanced features for digital zoom.

CCTV Camera Type N – The Internet Protocol (IP) PTZ Camera System for Night (low light) viewing may be provided in an outdoor external positioner or dome. Night vision will be provided by thermal imaging. Images shall be provided in 640 X 480 resolution with dual output stream digital video in H.264, MPEG-4, or M-JPEG formats.

CCTV Camera Type Tc – The Internet Protocol (IP) Turret Camera System uses a built in encoder to provide H.264 or Moving Picture Experts Group's MPEG4 part 10 video compression technology in accordance with the International

Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 14496-10:2014 standard. This camera shall be compatible with the legacy NaviGator System. Ensure that the camera is capable of unicast and multicast operation. Ensure that the encoded video can be transmitted utilizing programmable bit rates. Ensure the camera supports, at a minimum, fixed bit rate mode. Ensure that the camera supports the National Transportation Communications for ITS Protocol (NTCIP) 1205 v1.08 Amendment 1 (2014). Ensure that the camera is capable of communication with other devices using transmission control protocol (TCP/IP). Ensure that the camera supports the communication links shown in the Plans. The camera must be capable of remote firmware upgrades via the communication interface.

CCTV Camera Type Th – The Internet Protocol (IP) High Definition Turret Camera System uses a built in encoder to provide H.264 or Moving Picture Experts Group’s MPEG4 part 10 video compression technology in accordance with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 14496-10:2009 standard and with a minimum pixel resolution of 1920 x 1080 and an aspect ratio of 16:9 which is able to support simultaneous broadcast of lower resolutions. It must be compatible with the NaviGator System and provides enhanced features for digital zoom.

CCTV Camera Type Tn – The Internet Protocol (IP) Turret Camera System for Night (low light) viewing may be provided in an outdoor external positioner. Night vision will be provided by thermal imaging. Images shall be provided in 640 x 480 resolution with dual output stream digital video in H.264, MPEG-4, or M-JPEG formats.

Video Encoder, Type B – Type B is a standalone, environmentally hardened encoder for a single video signal, suitable for field cabinet use and providing H.264 or Moving Picture Experts Group’s MPEG4 part 10 video compression technology in accordance with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 14496-10:2009 standard.

Video Encoder, Type C – Type C is a high density unit that supports multiple video signals and is suitable for control center use and providing the Moving Picture Experts Group’s MPEG4 part 10 (H.264) video compression technology in with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 14496-10:2009 standard.

Video Encoder, Type D – This encoder is a standalone, environmentally hardened encoder for a single video signal, suitable for field cabinet use that is compatible with the existing legacy encoder and decoder video systems, is capable of providing H.264 or MPEG4 part 10 along with part 2, and otherwise would not meet Type B requirements.

Video Encoder, Type E – This encoder is a high density encoder card unit for multiple video signals, with one encoder per video signal, suitable for control center use with the existing legacy encoder and decoder video systems and otherwise would not meet Type B requirements.

Video Encoder, Chassis Type E – This chassis is a high density mount unit that supports multiple Video Encoder Type C or Video Decoder Type C cards suitable for control center use with the existing legacy encoder and decoder video systems.

936.1.02 Related References

A. Standard Specifications

Section 639 – Strain Poles for Overhead Sign and Signal Assemblies

Section 680 – Highway Lighting

Section 682 – Electrical Wire, Cable and Conduit

Section 922 – Electrical Wire and Cable

Section 923 – Electrical Conduit

Section 925 – Traffic Signal Equipment

Section 939 – Communication and Electronic Equipment

B. Referenced Documents

American National Standards Institute (ANSI)

American Society of Testing and Materials (ASTM)

Electronic Industries Association (EIA)

FCC Rules Part 15, Sub-part J

- Insulated Cable Engineers Association (ICEA)
- International Electrotechnical Commission (IEC) ISO/IEC 14496-10:2009
- International Municipal Signal Association (IMSA)
- MIL-HDBK-454A
- MIL-STD-810F(3) Method 509 Procedure 1 – exterior salt atmospheres
- National Electric Code (NEC)
- National Transportation Communications for ITS Protocol (NTCIP) 1205 v1.08
- National Electrical Manufacturers Association (NEMA)
- NEMA-4
- Underwriter’s Laboratory Incorporated (UL)
- National Television Standards Committee (NTSC)

936.1.03 Submittals

This subsection and the following chart provide the Contractor with an outline of the submittal requirements for the equipment and components for all pay items in this Section 936. This chart is to be used as a guide and does not relieve the Contractor from submitting additional information to form a complete submittal package.

Section 936 Submittal Requirements									
Material	Specification Reference	Catalog Cuts	Mfg. Spec.	Materials Cert.	Lab Test	Install. Proced.	Test Plan	Maint. Proced.	Submittal Due Date (Cal. Days after NTP)
Training Plan	936.3.08		X			X	X	X	60 Days

Submit test procedures required for these items within sixty (60) calendar days after the Notice to Proceed and prior to any installation, unless noted otherwise in the Contract Documents.

Submit to the State ITS Engineer for approval one (1) electronic copy of service and maintenance documentation for all equipment, components and all other materials required within these specifications.

Provide submittal data that is neat, legible, and orderly. Neatly organize each package of submittal data and separate by hardware item. Use the “Materials Certification Package Index and Transmittal Form” for each pay item to document and list all material and components that are included in the submittal package. Any submittal data submitted without the Index/Transmittal form or that is incomplete will be rejected.

Products appearing on the Qualified Products List (QPL) are exempt from normal submittal requirements. These products have been evaluated by the Office of Traffic Operations and have proven their capability of meeting the appropriate Georgia Department of Transportation Specification. Any of these products may be used without submitting catalogue cuts, sampling or pre-testing. The Contractor shall submit a letter to the Engineer, stating which QPL items they will use. The Engineer and/or department designee must ascertain that the construction item is the same material identified on the appropriate QPL and will acknowledge receipt of these items in the project diary or as required by the Construction manual.

A. CCTV System; CCTV System, Retrofit Assembly; CCTV System, Retrofit Assembly (Furnish Only)

1. Camera System Assembly
Submit complete physical, performance, and operational materials submittal data for the camera system assembly and all associated components.
2. Camera System Assembly Mount
Submit complete physical, performance, and operational materials submittal data for the camera system assembly mount and all associated components and hardware.
3. Cabinet Interface Assembly

Submit complete physical, performance, and operational materials submittal data for the cabinet interface assembly and all associated components and hardware. Submit complete physical, performance and operational materials, submittal data for all cables, wire and connectors required for a complete and operational CCTV system. Submit cables and connectors as specified here and as recommended by the CCTV system manufacturer.

4. Submittal Review Demonstration Test Set

Submit demonstration test set(s) for Department evaluation after the Engineer approves the submittal materials for the equipment and materials listed below. The demonstration test sets shall be connected to and operated through the NaviGator system by the Engineer. Deliver the test set to the Department at the location specified by the Engineer. Request a delivery and test time a minimum of 30 days in advance. For projects with multiple camera installations, provide demonstration test sets of the materials, types and quantities as shown below:

- a. CCTV System (quantity 2)
- b. CCTV System, Retrofit Assembly (quantity 2)

A demonstration test set shall include all materials, components, assemblies, control software, and documentation of a CCTV system and shall be a complete, fully functional CCTV system.

B. Acceptance Testing

Submit acceptance test procedures and a desired acceptance test schedule.

C. Warranties and Guarantees

Submit materials submittal data providing complete example documentation on all manufacturers' warranties or guarantees on all CCTV system equipment and hardware components furnished, as required in Subsection 936.3.07.

D. Training

Prior to training, submit resume and references of instructor(s). Obtain approval from the Engineer that the instructor is qualified in his/her respective field. Submit the Training Plan within 120 days of the Notice to Proceed. Include in the training plan an outline of the training course. Obtain approval of the Training Plan from the Engineer. The Training Plan shall explain in detail the contents of the course and the time schedule of when the training shall be given. Coordinate actual training with installation schedules as approved by the Engineer.

936.2 Materials

936.2.01 CCTV Systems

Camera types are as specified on the plans, and may vary by location within project limits. Ensure that the individual components and assemblies of the CCTV System conform to the requirements specified in the following sections. Ensure that all equipment, materials, components and assemblies of the CCTV System conform to the CCTV manufacturer's requirements and recommendations.

A. Camera System Assembly

Follow these minimum requirements for a camera system assembly including the camera, dome assembly, lens, pan/tilt drive, and control electronics.

1. For dome enclosure cameras (Types B, C, and H)
 - a. Provide a downward-looking circular dome-shaped enclosure assembly. The enclosure shall have a maximum diameter of 14 in (356 mm) at its widest point and a maximum height of 22 in (559 mm) from the top of the housing assembly to the bottom point of the dome. The upper housing shall be constructed of a non-metallic UV-stabilized material of a light color, or constructed of an aluminum material with a heat-cured paint coating of an equivalent color. The lower housing shall be constructed of a UV-stabilized optically-correct acrylic material. The maximum weight of the complete and fully functional camera system assembly, including the camera, lens, pan/tilt drive, control electronics, environmental control components, housing assembly, and hub adapter shall be 25 lbs (11.4 kg).
 - b. Use an enclosure assembly that secures to the mounting bracket arm with a 1-1/2 in (37.5 mm) threaded pipe nipple. Hub adapters for the threaded pipe nipple on either the enclosure or the mounting arm, or both, are permitted.
 - c. All fastening and mounting hardware on or within the enclosure assembly shall be stainless steel.

- d. Pressurized enclosures are optional. Pressurized enclosure assemblies shall have an operating pressure range of 3-7 psi (21-48 kPa, use extra dry nitrogen, and be outfitted with a pressure relief valve and a Schrader valve for filling and evacuating the enclosure. Non-pressurized enclosure assemblies shall have a NEMA 4/IP-66 rating and be vented with a thermostat-controlled heater and blower.
- e. When an enclosure assembly requires a heater and a circulating blower fan for environmental (temperature and defogging) control, maximum electrical load for the heater shall be no more than 85 VA.
- f. Ensure that the CCTV camera system performs all required functions during and after being subjected to an ambient operating temperature range of -30° to 165° F (-34° to 74° C) as defined in the environmental requirements section of the NEMA TS2 standard. Verify that the CCTV camera manufacturer certifies its device has successfully completed environmental, shock, and vibration testing as defined in the environmental requirements section of the NEMA TS2-2003 standard.
- g. Ensure that the housing protects the camera and other internal components from rain, dust, corrosive elements, and typical conditions found at a roadside environment. Ensure that the CCTV camera, mounting hardware, and any other camera-related material that is exposed to the environment can withstand 90 mph (145 kph) wind speeds.
- h. Electrical power for the complete camera system assembly shall be per the manufacturer's recommendations and between 12V to 120V DC or single-phase AC utilizing a two-wire (not counting ground) supply from the cabinet interface assembly in the equipment cabinet. Do not use a dual-voltage power supply. Maximum electrical load with all subsystems operational, including the heater, shall be no more than 130 VA.
- i. For analog cameras (Type B), ensure that the camera produces an analog NTSC-compliant composite video output with a signal-to-noise ratio of 45dB or greater.
- j. Use a camera unit with an integrated camera sensor and zoom lens assembly. The camera shall use a CCD or CMOS image sensor and have a minimum resolution of 720 horizontal by 480 Picture Elements.
- k. The camera shall include on/off selectable automatic gain control and manual/automatic selectable white balance. The camera shall include an electronic shutter mode with user-selectable speeds of a minimum range from 1/60 second to 1/10,000 second. The camera unit shall provide an on/off selectable day/night function where the image sensing and output automatically switch between color and black-and-white imaging; fixed color or black-and-white imaging shall be user-controllable. The camera sensitivity shall be no less than 3.0 lux in color mode (1/60 second) and 0.5 lux in black-and-white mode (1/60 second, IR cut removed).
- l. Provide a camera unit with an integrated zoom lens of a minimum of 20X optical zoom and a minimum of 4X (HD Camera Type D shall have a minimum of 12X) digital zoom. The camera shall not employ any digital zoom functionality unless the lens is at the full limit of optical zoom and the zoom command continues to be applied, in which case the camera unit shall automatically switch from optical to digital zoom. The camera unit shall include on/off selectable automatic focus and manual/automatic selectable iris control.
- m. Use a pan/tilt drive for the camera unit that is fully-contained within the enclosure assembly. The drive shall be capable of 360 degree panning and at least 0 degree horizontal to 90 degree vertical looking downward tilting. The camera unit and pan/tilt drive shall provide automatic 180-degree image output flip at the bottom of the tilt travel. The camera unit and pan/tilt drive shall provide a minimum of eight privacy blackout zones, each zone being individually programmable to be on/off by the user. The panning speed, when a pan-left or pan-right command is applied by the user, shall be between 10 and 18 degrees per second. The tilting speed, when a tilt-up or tilt-down command is applied by the user, shall be between 4 and 10 degrees per second.
- n. Provide a system control interface to the camera system assembly that physically and logically supplies the user commands to and monitoring from the camera system assembly, including but not limited to pan, tilt, zoom, focus, position reporting, and configuration. The system control interface shall physically connect the camera system assembly to the cabinet interface. Provide a system control interface that is in compliance with NEC and all of the physical and operational requirements specified for a CCTV System. Provide the capability to set the communications through the system control interface or through the user control interface in the cabinet; do not

require the opening/disassembly of the camera system enclosure to set the communications address. Store all user configurable settings in non-volatile memory that is retained indefinitely upon loss of power.

2. For Turret Cameras (Types Tc, Th, and Tn)
 - a. Ensure that the CCTV camera system performs all required functions during and after being subjected to an ambient operating temperature range of -30° to 165° F (-34° to 74° C) as defined in the environmental requirements section of the NEMA TS2 standard. Verify that the CCTV camera manufacturer certifies its device has successfully completed environmental, shock, and vibration testing as defined in the environmental requirements section of the NEMA TS2-2003 standard.
 - b. Ensure that the housing protects the camera and other internal components from rain, dust, corrosive elements, and typical conditions found at a roadside environment. Ensure that the CCTV camera, mounting hardware, and any other camera-related material that is exposed to the environment can withstand 90 mph (145 kph) wind speeds.
 - c. Ensure that enclosure assemblies are environmentally rugged and compatible with the temperature, power, vibration, and shock requirements of NEMA TS-2, as well as the environmental dust and water resistance requirements of IEC 60529 IP66 and IP67 ratings.
 - d. Electrical power for the complete camera system assembly shall be per the manufacturer's recommendations and between 12V to 120V DC or single-phase AC utilizing a two-wire (not counting ground) supply from the cabinet interface assembly in the equipment cabinet. Do not use a dual-voltage power supply. Maximum electrical load with all subsystems operational, including the heater, shall be no more than 130 VA.
 - e. Use a camera unit with an integrated camera sensor and zoom lens assembly. The camera shall use a CCD or CMOS image sensor, with a minimum of 720 horizontal by 480 vertical active picture elements. The camera shall have a minimum resolution of 460 horizontal TV lines by 540 vertical TV lines.
 - f. The camera shall include on/off selectable automatic gain control and manual/automatic selectable white balance. The camera shall include an electronic shutter mode with user-selectable speeds of a minimum range from 1/60 second to 1/10,000 second. The camera unit shall provide an on/off selectable day/night function where the image sensing and output automatically switch between color and black-and-white imaging; fixed color or black-and-white imaging shall be user-controllable. The camera sensitivity shall be no less than 3.0 lux in color mode (1/60 second) and 0.5 lux in black-and-white mode (1/60 second, IR cut removed).
 - g. Provide a camera unit with an integrated zoom lens of a minimum of 20X optical zoom and a minimum of 4X (HD Camera Type D shall have a minimum of 12X) digital zoom. The camera shall not employ any digital zoom functionality unless the lens is at the full limit of optical zoom and the zoom command continues to be applied, in which case the camera unit shall automatically switch from optical to digital zoom. The camera unit shall include on/off selectable automatic focus and manual/automatic selectable iris control.
 - h. Use a pan/tilt drive for the camera unit that is fully-contained within the enclosure assembly. The drive shall be capable of 360 degree panning and at least 0 degree horizontal to 90 degree vertical looking downward tilting. The camera unit and pan/tilt drive shall provide automatic 180-degree image output flip at the bottom of the tilt travel. The camera unit and pan/tilt drive shall provide a minimum of eight privacy blackout zones, each zone being individually programmable to be on/off by the user. The panning speed, when a pan-left or pan-right command is applied by the user, shall be between 10 and 18 degrees per second. The tilting speed, when a tilt-up or tilt-down command is applied by the user, shall be between 4 and 10 degrees per second.
 - i. Provide a system control interface to the camera system assembly that physically and logically supplies the user commands to and monitoring from the camera system assembly, including but not limited to pan, tilt, zoom, focus, position reporting, and configuration. The system control interface shall physically connect the camera system assembly to the cabinet interface. Provide a system control interface that is in compliance with NEC and all of the physical and operational requirements specified for a CCTV System. Provide the capability to set the communications through the system control interface or through the user control interface in the cabinet; do not require the opening/disassembly of the camera system enclosure to set the communications address. Store all user configurable settings in non-volatile memory that is retained indefinitely upon loss of power.

3. Camera Type D – Fixed Camera. Fixed cameras shall be designed for outdoor applications meeting NEMA 4X or IP-66 rating requirements and include all necessary harness and cables to extend the video, power and data from the CCTV Camera location to the field cabinet. The enclosure shall be suitable for the location and meet all requirements as denoted above for other camera types. The lens shall have a minimum F-stop of 1.4 with a variable manual zoom of 5 – 50 mm. The iris shall support automatic or set to yield optical results under various outdoor lighting conditions. The camera shall provide all other functionality as required of other types to produce a fixed view of the roadway.
4. IP Cameras (Types C, D, and Tc) shall provide the same functionality as the analog camera unit, and shall include built in integral encoders (i.e., Ethernet ready). In addition, IP cameras shall meet the following minimum requirements:
 - a. Power over Ethernet (IEEE802.3af) or 24 VAC power input.
 - b. The integral video encoder in the dome assembly shall meet the exact same requirements for Video Encoder Type B, except that mounting/packaging, cable connectors, and power supply requirements shall be according to the camera manufacturer requirements. A serial console interface to the integral encoder is not required.
5. High Definition Cameras (Types H and Th) shall provide the same functionality as other IP (built in encoders) camera types, and in addition, shall meet the following minimum requirements:
 - a. HD 1080p resolution at 30 images per second (ips) and support simultaneous broadcast of lower resolutions
 - b. Minimum 20x optical zoom and 12x digital zoom
 - c. 16:9 aspect ratio
 - d. Digital image stabilization
6. CCTV Camera Types N and Tn – Internet Protocol (IP) PTZ Camera System for Night (low light) viewing shall provide video surveillance imaging for reliable video images clearly in near total darkness. Images shall be provided in 640 X 480 resolution with dual output stream digital video in H.264, MPEG-4, or M-JPEG formats.

936.2.02 Camera System Assembly Mount

Provide a camera system assembly mount that includes a mounting bracket arm, camera enclosure mount and disconnect, mounting straps, and incidental fastening hardware. All fastening and mounting hardware shall be stainless steel.

The mounting bracket arm shall be suitable for pole-mounted applications using mounting straps or bolts. The bracket shall be fabricated to exactly mate with the camera enclosure mount/disconnect/pipe nipple and any needed pole-mount adapter with no drilling or welding required. The bracket shall be fabricated from aluminum alloy with an exterior polyurethane coating, stainless steel, or mild steel with a heat-cured paint coating. All bracket coatings shall be light in color and corrosion resistant in accordance with MIL-STD-810F (3) Method 509 Procedure 1 for exterior salt atmospheres.

Unless otherwise indicated on the plans, use a mounting bracket arm that locates the vertical centerline of the camera enclosure from 14 in (356 mm) to 24 in (610 mm) from the exterior surface of the support pole. The mounting bracket arm shall provide for cable entrance through the base of the bracket directly from the support pole and from the exterior through a rain tight opening on the underside of the bracket and adjacent to the support pole. The bracket arm shall provide sufficient opening to fully enclose the cables. Provide non-metallic cable protection grommets for both cable entrances. Unless otherwise shown in the Plans, mount the bracket arm to the support pole using a minimum of two ½ in (12.5 mm) or greater stainless steel mounting straps.

936.2.03 Camera Lowering System Assembly Mount

Where specified on the plans, provide a camera lowering system that includes a mounting bracket arm, self-aligning docking system, video and power surge protection. The unit will be self-contained, suitable for pole-mounted applications using straps or bolts. All fastening and mounting hardware shall be stainless steel. The lowering cable(s) shall be stainless steel. All bracket coatings shall be light in color and corrosion resistant in accordance with MIL-STD-810F (3) Method 509 Procedure 1 for exterior salt atmospheres. The lowering device shall have a support capacity of 55 lbs. (25 Kg.), and shall provide for camera systems at varying heights above ground level to match the height of the mounting structure. Electrical power for the complete camera lowering system assembly shall be per the manufacturer's recommendations and 120 VAC.

936.2.04 Cabinet Interface Assembly

Use a cabinet interface assembly that provides electrical service for the camera system assembly and provides the user control interface connection to the NaviGator system and/or user personnel. Install the cabinet interface assembly in the equipment cabinet. All fastening and mounting hardware shall be stainless steel. The cabinet interface panel assembly includes the following:

- CCTV Interface Enclosure
- Camera System Assembly Power Supply with surge suppression
- Terminal blocks and video cable surge suppression for camera system assembly cabling
- User control interface to the NaviGator system and/or user personnel with surge suppression

The NaviGator Standard CCTV Control Protocol (hereinafter called the “CCTV Standard Protocol”) is specified below and shall connect to the user control interface unit through an RS-232 serial data interface directly from the NaviGator system. Provide the control software with an unrestricted, non-cancelable user license for the Department’s use with any NaviGator equipment at any location. Furnish three (3) copies each of the software, license, appropriate RS-232 cable, and user documentation per project.

A. CCTV Standard Protocol

1. General

For all camera types, use the NaviGator Standard CCTV Control Protocol (hereinafter called the “CCTV standard protocol” or “standard protocol”) for CCTV system control communications between the camera unit and the GDOT NaviGator central system to achieve a fully functional communications interface to utilize all of the capabilities and functions of the camera. Implement the standard protocol for all CCTV equipment installed on this project. The CCTV standard protocol governs all control communications between the NaviGator central system (hereinafter called the “host”) and the CCTV system.

2. Interface

For Type B cameras, the CCTV System (hereinafter called the “remote”) shall communicate using the CCTV standard protocol over an RS-232 serial interface. Data is transmitted using 1 start bit, 8 data bits, and 1 stop bit (no parity) at a baud rate of 9600.

Each remote shall be identified by a unique integer address between 1 and 233. This address is set during installation and shall not be altered using the standard protocol. The address is included in messages to identify the intended recipient of commands from the host and responses from the remote.

936.2.05 Cabling and Connectors

Provide cabling and connectors between the camera system assembly and the cabinet interface assembly as shown in the CCTV system detail drawings and in the Plans. Label all cables. All cables shall meet industry and manufacturer recommendations.

When required for the camera application, coaxial video signal cables will be provided with labels attached at both ends of each cable. Coaxial cables will use BNC connectors with gold-plated center pins on the video signal cables; use only connectors recommended by the cable manufacturer.

Provide control cable with labels attached at both ends of the cable. Terminate control cable in the equipment cabinet as shown in the CCTV system detail drawings in the plans and as recommended by the CCTV system manufacturer. Ground or bond any pair shielding and any unused conductors in accordance with the CCTV system manufacturer’s recommendations.

For IP Cameras, provide communications cabling (Outside Plant Category 5) as recommended by the CCTV system manufacturer. Label all cables. Separate power cables must be clearly labeled as such and meet manufacturer recommendations. When Power over Ethernet cameras are provided, cabling must be sized and rated in accordance with manufacturer recommendations and clearly labeled as such.

936.2.06 Video Encoder (All Types)

Provide a Video Encoder in accordance with the minimum requirements below for the encoding of analog video inputs and transmission as digital streams over a network.

A. Video Encoder, Type A

Not Used

B. Video Encoder, Type B

Video Encoder, Type B is a standalone, environmentally hardened encoder for a single video signal, suitable for field cabinet use.

1. General

- a. All encoders provided by the Contractor shall be new and shall be from the same manufacturer and be fully compatible and interoperable with each type provided.
- b. All encoder types provided by the Contractor shall be fully compatible and interoperable with the GDOT existing network equipment.
- c. Mean Time Between Failures (MTBF): Encoders shall have a minimum MTBF of 20,000 hours.
- d. Latency: The end-to-end system latency between the Encoder and Decoder appliances shall be no more than 300 ms, not including network delays. The encoders shall support various frame adjustments to minimize latency.
- e. Remote Control: Encoders shall be remotely adjustable via a video management system or command set so that a technician can adjust image quality controls for contrast, brightness, hue and color levels.
- f. Video equipment shall support the NTSC signal format.
- g. Furnish rack-mountable or shelf-mountable units.
- h. Rack-mountable units shall include integrated brackets for mounting in standard EIA 19-inch rack rack-mountings.

2. Physical and Environmental Requirements.

- a. The Video Encoder shall have the following ports as a minimum:
 - Network: 10/100 Mbps RJ-45 or as directed by Engineer.
 - Video Connector: BNC
 - Serial Data Interface: One (1) minimum RJ-45 port/connector.
 - Serial port may utilize D-sub connectors or terminal block connections as approved by the Engineer.
- b. In locations where there is more than one video source and Encoders with multiple video ports are approved by Engineer, each video input port shall meet all the video and data requirements of Video Encoder Type B independently.
- c. The video input performance measures shall comply with NTSC and EIA requirements, including the EIA-170 standard, with a nominal composite video of 1 volt peak-to-peak (V_{p-p}). The equipment shall have an electrical impedance of 75 ohms.
- d. Operating temperatures and humidity shall comply with the NEMA TS2-2003 standard
- e. Ventilation fans are not permitted.
- f. Encoders shall be installed in a field cabinet with protection from moisture and airborne contaminants, blowing rain, wind, blowing sand, blowing dust, humidity, roadside pollutants, vandalism, and theft.
- g. Encoders shall be resistant to vibration and shock, and conform to Sections 2.1.9 and 2.1.10, respectively, of the NEMA TS2-2003 standard.
- h. Encoders for field site locations shall be PCB conformal coated to provide a level of protection from humidity, contaminants, dust, pollution, etc.
- i. Encoders shall provide LED status indicators for local status display of analog video input, serial data interface activity, network interface activity and power.

- j. Cable connections (data/video/power) shall require no tools for installation or removal and be designed with positive locking devices such that they will not vibrate loose.
 - k. Provide external markings for all connectors and indicators. Replaceable components shall be permanently marked and traceable to the supplied documentation, including schematics and parts list.
 - l. The external markings shall include the product function name, model number, serial number, and manufacturer's name.
 - m. All parts required for a completed video system shall be made of corrosion-resistant materials, such as stainless steel, anodized aluminum, brass, or gold-plated metal.
 - n. All individual Encoders shall be shelf, rack (19")/module, or DIN rail mountable. Other mounting options may be submitted for review and approval by the Engineer.
 - o. Nominal power input voltage of 120 VAC, 60 Hz. ± 3 Hz.
 - p. Maximum power consumption of 20 watts.
 - q. If the device requires operating voltages of less than 120 VAC, the appropriate voltage converter shall be supplied. All voltage conversion devices shall also be temperature hardened as specified herein for location (field or central).
 - r. The equipment or its voltage converter shall operate within a voltage range of 90 VAC to 135 VAC.
 - s. Encoders shall provide for automatic recovery from an over or under voltage condition when prime power has returned to the tolerance values specified herein. All configuration parameters shall be stored in non-volatile memory and no reprogramming or manual adjustments shall be required upon power recovery.
3. Video Data Requirements
- a. The Encoder shall be capable of streaming a minimum of the following Video Compression Technology types:
 - Stream 1: H.264 (Video Coding Experts Group (VCEG)/Moving Picture Experts Group)
 - Stream 2: H.264 (Video Coding Experts Group (VCEG)/Moving Picture Experts Group)
 - Snapshot: JPG full-frame capture
 - b. The Encoder shall be capable of streaming multiple bandwidth and compression types simultaneously per video input channel.
 - c. The Encoder shall support streaming multicast and unicast streams simultaneously.
 - d. The Encoder shall have the ability to automatically initiate and stream a multicast stream upon starting without any remote request to join the multicast group.
 - e. The Encoder shall support multiple simultaneous Real Time Streaming Protocol (RTSP) requests.
 - f. The Encoder shall be able to supply multiple unique and independent video streams with frame rate, bit rate, and image size settings adjustable through an RTSP request.
 - g. The encoder shall support a minimum of 2 simultaneous unique and independent H.264 video streams with frame rate, bit rate, and image size settings adjustable per video input channel.
 - h. Encoders shall be a hardware-based network device able to accept a minimum of one analog National Television System Committee (NTSC) video input and encode for transport across IP networks.
 - i. Encoders shall be specifically designed for network operation, and adhere to ISO standards.
 - j. Support the following minimum encoded resolutions:
 - Stream 1: NTSC – Full D1
 - Stream 2: CIF/SIF
 - Snapshot: NTSC – Full D1

- k. Dynamic bandwidth control: Provide, at the minimum, the following rates (The data rate shall be defined as the maximum committed bandwidth to be utilized, which includes data bursting.).
 - Stream 1: 3 Mbps at D1
 - Stream 2: 1 Mbps at CIF/SIF
- l. Bandwidth increments shall be user configurable via the network, independently per stream and snapshot. The minimum bandwidth setting shall be 56Kbs or less.
- m. Encoder streams shall be capable of being set to variable or constant bit rates.
- n. The default bandwidth for the Encoders as furnished shall be set to 2Mbps when communicating over fiber and 56kbs when communicating otherwise.
- o. Provide on-board buffered video memory for protection against potential network disruptions.
- p. Encoders shall be capable of providing JPG snapshots and transfer image via FTP either by push or pull at a user-defined interval between 60 and 300 seconds.
- q. Encoded streams shall be fully compatible with the NaviGator software decoding system and with VLC (Video LAN Client.)
- r. The encoder system, including processor, internal memory access and all data paths, shall operate with the following stream settings running simultaneously with no performance degradation of any stream, serial data interface, or device management interface:
 - Stream 1: 2Mbps/NTSC – Full D1/30 frames per second/RTP
 - Stream 2: 192Kbps/SIF/15 frames per second/RTP
 - Snapshot: NTSC – Full D1/120 second capture interval

4. Network Requirements

- a. Encoders shall meet the following minimum network requirements:
- b. Network connection shall be Ethernet Compliant IEEE 802.3, 802.3u, and 802.3x; 10/100 Mbps or higher, auto sensing full/half-duplex operations.
- c. Encoders shall provide encapsulation of each of the video streams in UDP packet and TCP packets, depending on stream configuration, for network transmission.
- d. Encoders shall connect to a network device (i.e., Ethernet switch/router, IP wireless device, etc.) via a RJ-45 connector through Category 5e or higher quality stranded patch cords.
- e. All network RJ-45 ports shall be standard EIA/TIA-568-A pin-outs and shall be rated at 10/100Mbps or greater.
- f. All Encoders provided by the Contractor shall be fully interoperable without customization or the addition of appliances within either the remote or primary communications network. All devices shall be fully interoperable with the backbone communications network.
- g. Static management interface IP Addressing (class A, B, and C).
- h. Static IP addressing of the multicast group individually and independently for each stream.
- i. RTP, UDP, Unicast and IP Multicast (Internet Group Multicast Protocol / IGMP V2) features for digital video transmission, individually and independently for each stream.
- j. Encoders shall support Real Time Streaming Protocol (RTSP) over RTP, individually and independently for each stream.
- k. Encoders shall support multiple stream requests, individually and independently for each stream.

5. Serial Data Interface Requirements

The Encoder shall meet the following minimum serial data interface requirements:

- a. The Encoder shall provide bi-directional serial communications over Ethernet 10/100 Base-TX via the following methods:
 - Encoder serial port to Decoder serial port data stream.
 - IP socket to Encoder serial port by TCP protocol.
 - b. Each serial port shall provide full-duplex serial interface and data rates up to 115.2 Kbps (minimum).
 - c. Serial port shall be software configurable, locally or over the network, to EIA-232/422/485 mode of operation as defined by the EIA for data format, data rate, and data structure (e.g., baud rate, the number of bits, parity, stop bits, flow control, etc.) via the management software provided.
 - d. No serial adaptors or interface converters shall be permitted.
 - e. Encoders shall be capable of using the serial interface port to support PTZ camera control functions.
 - f. Encoder serial port shall provide IP addressing and socket number selection and provide the capability to establish an IP connection directly from an operator workstation or server to any Encoder IP address and socket number to transport serial data, independent of whether or not any video stream for that encoder is being viewed.
6. On Screen Display Requirements
- The Encoder shall provide the following On-Screen Display (OSD):
- a. Encoders shall support a static text insertion capability on all streams and shall be capable of inserting a minimum of two (2) user configurable text messages of at least 20 characters in length on separate lines, in user-configurable positions anywhere on the image.
 - b. Encoders shall support JPG image insertion on all streams in either the upper left or upper right positions in the image, using a JPG file(s) stored in the Encoder's configuration.
 - c. JPG image insertion shall be scalable per stream according to the stream resolution, or there shall be the capability to insert a different JPG image file for each stream.
 - d. Encoders shall have the option to display or not display the OSD.
7. Management Requirements
- a. Encoders shall be manageable through SNMP (v2), HTTP, FTP/TFTP, and/or Telnet/CLI.
 - b. Encoders shall have a NTP or SNTP client.
 - c. The management system shall be provided to remotely configure and diagnose the Encoder.
 - d. Have capability to reset/reboot and firmware upload via the methods listed above.
 - e. Have the capability to remotely change any of the device configuration settings including bit rates, image resolution and compression settings and serial interface type.
 - f. Provide pre-defined optimized video compression and streaming settings for various bit rates.
 - g. Provide update capability for the firmware in the Encoder from the central site. Ability to access the serial number, firmware number, IP address and equipment configuration.
 - h. Have the capability to upload firmware to multiple units automatically.
 - i. Provide ability for remote firmware upgrades.
 - j. Provide a command-line interface on the console port for local management.
 - k. Provide administrative access control via a configurable password.
 - l. Provide support for managing the administrative security parameters via both the Local Management and Remote Management interfaces required herein.

- m. Provide support for managing the following video streaming parameters via the Remote Management functionality required herein.
 - Target address and port (per stream)
 - TTL parameter
 - Resolution (per stream)
 - Frame rate (per stream)
 - I/P ratio (per stream)
 - Encoding bit rate (per stream)
 - On-screen display

C. Video Encoder, Type C – Card

Video Encoder, Type C- Card is a high density encoder unit (card) for multiple video signals, with one encoder per video signal, suitable for control center use in a slot based chassis.

1. General

- a. Each encoder of a Video Encoder Type C- Card shall meet all the Video Encoder, Type B requirements except the physical requirements as noted in section 936.2.06.B.
- b. All Contractor provided Video Encoder Type C- Cards shall be compatible with, and of the same make as Video Encoder, Type C – Chassis provided by the Contractor.
- c. All Contractor provided Video Encoder Type C- Cards shall be compatible with, and of the same make as standalone Video Encoder, Type B provided by the Contractor.

2. Physical

- a. Each Video Encoder Type C- Card shall include a minimum of 4 encoders per card with a corresponding number of BNC ports per encoder.
- b. Each Video Encoder Type C- Card shall include one RJ-45 Network port: 10/100 Mbps.
- c. Video Encoder Type C- Card shall be fully contained and obtain power from the Video Encoder, Type C Chassis.

D. Video Encoder, Type C – Chassis

Video Encoder, Type C - Chassis is a high density rack mount unit that supports multiple Video Encoder Type C or Video Decoder Type C cards suitable for control center use.

1. General

All Contractor provided Video Encoder Type C- Chassis shall be compatible with, and of the same make as Video Encoder, Type C – Cards provided by the Contractor

2. Physical

Chassis shall support a minimum of 12 Video Encoder, Type C cards, or 12 Video Decoder, Type C cards, or a combination thereof up to the minimum total cards.

- a. Chassis shall be 7U or less and be 19” rack mountable.
- b. Each Chassis shall be capable of operating on 1 internal power supply.
- c. Each Chassis shall be capable of supporting a minimum of 2 internal power supply.

E. Video Encoder, Type D

Video Encoder, Type D is a standalone, environmentally hardened encoder for a single video signal, suitable for field cabinet use that is compatible with the existing legacy encoder and decoder video systems and otherwise would not meet Type B requirements.

1. General

Encoders of this Type shall be of the same make and model of encoder(s) that it shall replace, share communication in a drop and add link with, or with the decoder that shall decode it's video, unless otherwise approved by the Engineer.

F. Video Encoder, Type E – Cards

Video Encoder, Type E-Cards is a high density encoder unit for multiple video signals, with one encoder per video signal, suitable for control center use with the existing legacy encoder and decoder video systems and otherwise would not meet Type B requirements.

1. General

Encoder Cards of this Type shall be of the same make and model of the Encoder Card(s) that it shall replace, or with the Encoder Card(s) that resides in the same chassis that it shall be added to unless otherwise approved by the Engineer.

G. Video Encoder, Type E – Chassis

Video Encoder, Type E - Chassis is a high density rack mount unit that supports multiple Video Encoder Type C or Video Decoder Type C cards suitable for control center use with the existing legacy encoder and decoder video systems and otherwise would not meet Type B requirements.

936.2.07 Video Decoder (All Types)

A. Video Decoder, Type A

Not Used

B. Video Decoder, Type B

Video Decoder, Type B is a standalone decoder for the decoding of IP streams of the formats compatible of the Video Encoder Type B streams into a standard NTSC analog video stream output.

1. General

- a. All Video Decoder Type B shall meet all the requirements of a Video Encoder Type B unless otherwise stated.
- b. Video Decoder Type B shall be new, from the same manufacturer, and be fully compatible and interoperable with each type of encoder and decoder provided.

2. Physical and Environmental

Video Output Connector: BNC

- a. The video output performance measures shall comply with NTSC and EIA requirements, including the EIA-170 standard, with a nominal composite video of 1 volt peak-to-peak (Vp-p). The equipment shall have an electrical impedance of 75 ohms.

3. Video Data Requirements

- a. The Decoder shall be capable of decoding a minimum of the following Video Compression Technology types:
 - H.264 (Video Coding Experts Group (VCEG)/Moving Picture Experts Group)
 - MPEG -4 (Moving Picture Experts Group)
 - MJPEG Motion JPEG (Moving Picture Experts Group)
- b. The Decoder shall support joining multicast groups and decode the streams of the Type and video Compression technology listed above.
- c. The Decoder shall support decoding unicast streams of the Type and video Compression technology listed above.
- d. The Decoder shall support decoding of streams from RTSP requests of the Type and video Compression technology listed above
- e. The Decoder shall be able to decode unique and independent video streams with frame rate, bit rate, and image size settings adjustable through an RTSP request.

- f. Decoders shall be a hardware-based network device able to provide a minimum of one analog National Television System Committee (NTSC) video output and decode IP video transported across IP networks.
 - g. Decoders shall be specifically designed for network operation, and adhere to ISO standards.
 - h. Support the following minimum encoded resolutions:
 - NTSC - Full D1
 - CIF/SIF
 - QCIF/QSIF
 - Decoder streams shall be capable of decoding streams set to variable or constant bit rates
4. Network Requirements. Decoders shall meet the following minimum network requirements:
Network connection shall be Ethernet Compliant IEEE 802.3, 802.3u, and 802.3x; 10/100 Mbps or higher, auto sensing full/half-duplex operations.
5. On Screen Display Requirements
- a. Decoders shall support a static text insertion capability and shall be capable of inserting a minimum of one (1) user configurable text messages of up to 20 characters in length.
 - b. Decoders shall be able to generate a date and time stamp in the video stream and shall be synchronized to a time-server on the network.
 - c. Decoders shall be able to display camera title in the video stream.
 - d. Decoders shall have the option to display or not display the on-screen text.
6. Management Requirements
- a. Decoders shall be manageable through SNMP (v2), HTTP, FTP/TFTP, and/or Telnet/CLI.
 - b. The management system shall be provided to remotely configure and diagnose the Decoder.

C. Video Decoder, Type C – Card

Video Decoder, Type C- Card is a high density Decoder unit (card) for multiple video signals, with one Decoder per video signal, suitable for control center use in a slot based chassis.

- 1. General
 - a. Each Decoder of a Video Decoder Type C- Card shall meet all the Video Decoder, Type B requirements except the physical requirements as noted in section 936.2.06.B.
 - b. All Contractor provided Video Decoder Type C- Cards shall be compatible with, and of the same make as Video Decoder, Type C – Chassis provided by the Contractor
 - c. All Contractor provided Video Decoder Type C- Cards shall be compatible with, and of the same make as standalone Video Decoder, Type B provided by the Contractor
- 2. Physical
 - a. Each Video Decoder Type C- Card shall include a minimum of 4 Decoders per card with a corresponding number of BNC ports per Decoder.
 - b. Each Video Decoder Type C- Card shall include one RJ-45 Network port: 10/100 Mbps.
 - c. Video Decoder Type C- Card shall be fully contained and obtain power from the Video Decoder, Type C Chassis.

D. Video Decoder, Type C – Chassis

Video Decoder, Type C - Chassis is a high density rack mount unit that supports multiple Video Decoder Type C or Video Decoder Type C cards suitable for control center use.

- 1. General

- a. All Contractor provided Video Decoder Type C- Chassis shall be compatible with, and of the same make as Video Decoder, Type C – Cards provided by the Contractor
- 2. Physical
 - a. Chassis shall support a minimum of 12 Video Decoder, Type C cards, or 12 Video Decoder, Type C cards, or a combination thereof up to 12 total cards.
 - b. Chassis shall be 7U or less and be 19” rack mountable.
 - c. Each Chassis shall be capable of operating on 1 internal power supply.
 - d. Each Chassis shall be capable of supporting a minimum of 2 internal power supply.

E. Video Decoder, Type D

Video Decoder, Type D is a standalone, environmentally hardened Decoder for a single video signal, suitable for field cabinet use that is compatible with the existing legacy Decoder and decoder video systems and otherwise would not meet Type B requirements.

1. General

Decoders of this Type shall be of the same make and model of Decoder(s) that it shall replace, share communication in a drop and add link with, or with the decoder that shall decode it’s video, unless otherwise approved by the Engineer.

F. Video Decoder, Type E – Cards

Video Decoder, Type E-Cards is a high density Decoder unit for multiple video signals, with one Decoder per video signal, suitable for control center use with the existing legacy Decoder and decoder video systems and otherwise would not meet Type B requirements.

1. General

Decoder Cards of this Type shall be of the same make and model of the Decoder Card(s) that it shall replace, or with the Decoder Card(s) that resides in the same chassis that it shall be added to unless otherwise approved by the Engineer.

G. Video Decoder, Type E – Chassis

Video Decoder, Type E - Chassis is a high density rack mount unit that supports multiple Video Decoder Type C or Video Decoder Type C cards suitable for control center use with the existing legacy encoder and decoder video systems and otherwise would not meet Type B requirements.

1. General

Encoder Chassis of this Type shall be of the same make and model of the Encoder Chassis that it shall replace unless otherwise approved by the Engineer.

936.2.08 Delivery, Storage, and Handling

For Furnish Only items, provide all materials in protective packaging suitable for shipping and storage. Label all boxes with contents, including manufacturer name, model, serial numbers, and project number. Package each product/system in individual boxes as units of one complete unit. Multiple boxes for one assembly is acceptable, but multiple assemblies in the same box is not. Deliver assemblies to the Department at the location specified by the Engineer. Deliver at one time the full quantity of complete assemblies as shown in the Plans; multiple deliveries are not acceptable.

936.3 Construction Requirements

Ensure that all construction for the equipment, materials, components and assemblies of the CCTV System specified conform to the CCTV manufacturer’s requirements and recommendations.

936.3.01 Personnel

Not applicable

936.3.02 Equipment

Not applicable

936.3.03 Preparation

Not applicable

936.3.04 Fabrication

Not applicable

936.3.05 Construction

A. General Requirements

Request that the Department establish the utility service(s) required for a CCTV installation as described in Section 682.

B. CCTV System, All Types

1. Installation Requirements

Mount the camera system assembly and the mounting bracket arm at the cardinal direction and height as shown in the Plans, and so the pole is not obstructing the camera's view of the roadway or traffic signals.

Install cables between the camera system assembly and the equipment cabinet inside new hollow metal or concrete support poles unless otherwise specified. Where devices are installed on existing wood poles, install cabling on the wood poles in rigid metal conduit risers of minimum 2 in (50.8 mm) diameter. Use weather heads on all nipple and conduit openings. Neatly install and route cabling to minimize movement in the wind and chafing against the pole, device or bracket. Form a drip loop at the weather head and route cabling to prevent water entry into the weatherhead or mounting bracket arm. Install the mounting bracket arm no more than 8 in (204 mm) above the weatherhead, and install a drip loop that is no more than 6 in (152 mm) below the weatherhead at the loop's lowest point.

Install the cabinet interface assembly components in the equipment cabinet as shown in the CCTV system detail drawings. Neatly arrange and dress all wiring, firmly lace or bundle it, and mechanically secure the wiring without the use of adhesive fasteners. Route and secure all wiring and cabling to avoid sharp edges and to avoid conflicts with other equipment or cabling. Route all CCTV cables separate from any 120VAC power wiring or surge suppressor ground wiring. Neatly coil and dress between 3 ft (1 m) and 5 ft (1.5 m) of cables in the bottom of the cabinet. Dress and route grounding wires separately from all other cabinet wiring and with the minimum length possible between the suppressor and the ground bussbar. Do not splice any cable, shield or conductor used for video, control, communications signaling, power supply, or grounding.

Fasten all components of the cabinet interface assembly to be mounted on the equipment cabinet side panel or on the CCTV Interface Enclosure with stainless steel hex-head or Phillips-head machine screws. Install the screws into tapped and threaded holes in the panels. Fasten stud-mounted components to a mounting bracket providing complete access to the studs and mounting nuts. All fastener heads and nuts (when used) shall be fully accessible within the equipment cabinet, and any component shall be removable without requiring removal of other components, panels, or mounting rails. Do not use self-tapping or self-threading fasteners.

2. CCTV System Configuration

Program and configure the CCTV system in accordance with the procedure below. Provide all required documentation in writing with all data recorded in the format of the NaviGator Standard CCTV Control Protocol. Perform the CCTV system configuration in accordance with the acceptance procedures in subsection 936.3.06. Configure each CCTV system with the communications address specified by the Department, prior to any acceptance testing at a given CCTV system site. Configure the communications address as "001" unless otherwise shown in the Plans or directed by the Engineer.

GDOT's "ITS Surveillance Camera Control Integration and Calibration Procedure" is as follows:

- a. Record the position status setting for the full pan left and pan right stops. The pan left and pan right stops are defined as the camera positions when the pole initially comes into view from either direction at maximum zoom.
- b. Record the position status setting and angle (degrees from horizon) for maximum tilt up and maximum tilt straight down (90 degrees down from horizontal).
- c. Record the position status settings for each end of maximum focus range.
- d. Record the position status settings for maximum zoom out and zoom in.

e. Provide to the Department the following information from each field installation site:

- Location (as shown in Plans)
- Height of camera (ft) above travel lanes
- Azimuth (compass heading in degrees at camera's right stop as defined above)
- Azimuth (compass heading in degrees at camera's left stop as defined above)
- Device ID as shown on the Plans (example: CAM001)
- CCTV system communications address (example: 001)
- IP address, Subnet mask, Gateway port/socket of serial port on Encoder
- UDP Ports
- Multicast address
- Video switch input port (when connected)
- Comments

3. As-Built Drawings

Furnish as-built CCTV system wiring diagrams, identified by location. Include all wiring, cabling, conductor function, connector type and connector pinouts in an electronic (PDF) format.

936.3.06 Quality Acceptance

A. General

Acceptance testing of CCTV System, all Types consists of three phases: 1) field installation testing; 2) CCTV system site testing; and 3) burn-in period. After the Engineer's granting of burn-in period completion, obtain CCTV system acceptance. Perform acceptance testing for all equipment, hardware and work provided under this Contract, including each CCTV video surveillance field installation assembly and all associated communications hardware at a control center or communications hub. Perform all testing in the presence of the Engineer. Notify the Engineer of a desired acceptance test schedule no less than fourteen calendar days prior to beginning the testing except for testing using the NaviGator software and existing NaviGator control center and communications equipment. For acceptance testing using the NaviGator software and existing NaviGator control center and communications equipment, coordinate this testing with the Engineer no less than 30 days prior to the start of this testing.

Except as provided herein regarding the Department's NaviGator software, develop, provide all equipment for, and perform all acceptance testing for all CCTV system equipment, hardware and work. Develop detailed and thorough test procedures with full test plan descriptions, test and measurement equipment listings, and test results data sheets. Submit these test plans to the Engineer for approval. The Engineer will notify the Contractor of the approval or disapproval of the test procedures; only test procedures approved by the Engineer can be used. Provide all necessary testing and measurement equipment.

Make the acceptance testing plan a detailed and thorough procedure for both the field installation test and the CCTV system site test. Demonstrate that the CCTV system equipment, hardware and work meet all requirements of the Contract. These requirements include but are not limited to all design, construction, materials, equipment, assembly, documentation of manufacturer's certification of assembly and configuration, environmental, performance, communications, video and data communications signal strength and clarity, compatibility with the NaviGator software, and documentary requirements of the Contract.

Prior to the beginning of any acceptance testing at a given CCTV system site, complete all configuration and documentation associated with GDOT's "ITS Surveillance Camera Control Integration and Calibration Procedure," described in Subsection 936.3.05.B. Be prepared to demonstrate such work.

B. Field Installation Test

Perform the Field Installation Test as an onsite test of the complete field installation assembly less the communications components; no acceptance testing at a given site can begin until all work associated with that site is complete, not including the communications components. For the field equipment installation test, use a PC system, CCTV Embedded Protocol control software, and a color video monitor to demonstrate full operation of the CCTV site. Demonstrate operation to include pan, tilt, focus, zoom, iris, position feedback, and communications address configuration. Measure the video signal strength at the video connector of the communications equipment.

C. CCTV System Site Test

For the CCTV System Site Test, demonstrate proper CCTV system performance at the TMC or other control center determined by the Department. Perform the CCTV System Site Test only after successful completion of the field

installation acceptance test. Demonstrate the complete video image, camera/lens control, and communications operation from each CCTV site to the TMC. Use the NaviGator software and existing NaviGator control center and communications system to demonstrate the compatibility of the CCTV equipment and installation in its permanent NaviGator configuration. Verify data communications (pan, tilt, focus, zoom, iris, position feedback) from the TMC as defined in the Department-approved test procedures.

D. Burn-in Period

1. General Requirements

Provide a 30-day burn-in period for all work and equipment included in the Contract. The burn-in period shall consist of the field operation of the CCTV system in a manner that is in full accordance with the CCTV system requirements of the Plans and Specifications. An acceptance test procedure is not required for the system burn-in.

Conduct only one (1) burn-in period on the entire Contract. Commence with the burn-in period only after meeting all of the following requirements:

- a. All work required in all Contract documents for CCTV (may be combined with construction contract) (except this burn-in period) has been completed and inspected by the Engineer.
- b. Successfully complete all Acceptance Testing.

Commence with the burn-in period upon written authorization by the Department to commence. Terminate the burn-in period 30 consecutive days thereafter unless an equipment malfunction occurs. Stop the burn-in period for the length of time any equipment is defective. After repairing the equipment so that it functions properly, resume the burn-in period at the point it was stopped.

Successful completion and acceptance of the burn-in period will be granted on the 30th day unless any equipment has malfunctioned during the 15th through 30th day of the burn-in period. If any equipment has failed during the 15th through 30th day, final acceptance will be withheld until all the equipment is functioning properly for 15 days after repair.

When one specific piece of equipment has malfunctioned more than three times during the 30 day burn-in period, replace that unit with a new unit at no cost to the Department. Multiple failures of equipment in different locations shall constitute a failure of the 30 day burn-in period. The Contractor shall investigate the equipment failure and shall give a full report to the Engineer. The Contractor shall replace the failed devices and shall restart the burn-in period at Day 1, once those devices have been replaced and retested.

2. Contractor Responsibilities

During the burn-in period, maintain all work under this Contract in accordance with the Specifications. Restore any work or equipment to proper operating condition within 48 hours after notification.

3. Department Responsibilities

Department responsibilities during the burn-in period will be as follows:

- a. Expeditious notification of Contractor upon failure or malfunction of equipment
- b. In the event that the Contractor does not provide the services enumerated above under his Contract responsibilities, the Department or its authorized agents may in the interest of public safety take emergency action to provide for adequate traffic control. Pay any costs incurred as a result of these emergency actions. Such action by the Department will not void any guaranties or warranties or other obligations set forth in the Contract.

4. Burn-In Period Acceptance

The Department will make burn-in period acceptance after satisfactory completion of the required burn-in period and on the basis of a comprehensive field inspection of the complete CCTV system in accordance with the specifications. Upon burn-in period acceptance but prior to Final Acceptance of the entire Contract, maintain the complete CCTV system in accordance with the requirements of Subsection 936.3.07.

E. Bench Acceptance Test

For retrofit assemblies, perform the bench acceptance test as an onsite test for all assemblies furnished as shown in the Plans. Furnish a benchtop stand and associated hardware for the camera system assembly mount that securely holds the camera system assembly while the camera is being operated. For the bench acceptance test, use a PC system, CCTV Embedded Protocol control software, and a color video monitor to demonstrate full operation of the CCTV site.

Demonstrate operation to include picture quality, pan, tilt, focus, zoom, iris, position feedback, and communications address configuration.

936.3.07 Warranty and Maintenance

Equipment provided under this specification shall be warranted by the manufacturer to be free from defects in materials and workmanship for a minimum of three (3) years from Maintenance Acceptance.

The manufacturer's and supplier's warranties shall be transferable to the agency or user that is responsible for maintenance and shall be continuous throughout their duration.

During the warranty period, the manufacturer shall repair or replace any faulty equipment without cost to the purchaser, State of Georgia, or maintaining agency for all incidentals to the repair or replacement, including but not limited to parts, labor, or shipping.

The manufacturer shall be responsible for providing firmware or software updates associated with the CCTV system at no cost to the State of Georgia or maintaining agency during the warranty period. Further, the manufacturer is also responsible for ensuring that any updates will not degrade the original functionality of the product warranted.

The manufacturer and/or supplier shall provide consultation to the Department or user that is responsible for maintenance as needed at no cost during the warranty period for operating questions or problems that arise.

936.3.08 Training

Provide installation, operations, and maintenance training on the CCTV equipment at a site in the project area. Personnel trained by the various equipment manufacturers and authorized by said manufacturers shall perform the training. Include in the cost of training all supplies, equipment, materials, handouts, travel, and subsistence necessary to conduct the training. Furnish a training notebook in a labeled 3-ring binder to each trainee.

Provide installation, operations and maintenance training for up to twelve (12) people. Include in this training both classroom training and hands-on training. Limit in-shop and in-field training to group sizes of four (4) people at a time. Conduct all training in half-day sessions. Two half-day sessions may be held on the same day. The total of the training shall consist of at least six (6) clock hours of training for each participant. Provide a course content of, at a minimum, the following:

- Installation of all CCTV equipment
- Operations of all CCTV equipment
- Explanation of video quality
- Maintenance of all CCTV components
- Use of the CCTV embedded protocol control software
- Measurement of video signals
- Discussion of all warrantee clauses
- Hands-on use of CCTV equipment in signal shop environment for each trainee
- In-field maintenance training
- Video Encoders and Decoders
- Installation of all digital video compression system equipment
- Explanation of MPEG-4 digitized video
- Maintenance of all digital video encoder and decoder system components including software
- Measurement of digital video signals
- Hands-on use of digital video transport system equipment for each trainee

CCTV and Encoders/Decoders training shall be provided in conjunction with the digital video transport system training specified in Section 939. The total of the CCTV and video transport system training shall consist of at least eight (8) clock hours of training for each participant. Meet all video transport system training requirements of Section 939.

936.4 Measurement

936.4.01 CCTV System

CCTV systems, Type B, are measured for payment by the number actually installed, complete, functional, and accepted. Unless otherwise specified in the Plans, furnish and install the following minimum items for a CCTV system:

- Camera system assembly including the camera, lens, pan/tilt drive (except for Type D), control electronics and environmental enclosure.
- Pole-mounting hardware.
- Cabinet equipment, including but not limited to the cabinet interface assembly and all associated wiring, conductors, terminal blocks, and surge suppression.
- All weather heads, vertical conduit risers and conduit hardware on the CCTV support pole for power service, grounding, communications and control.
- All cables, connectors, hardware, interfaces, supplies, and any other items necessary for the proper operation and function of any CCTV system component with any other CCTV system component.

936.4.02 Encoders/Decoders

A. Video Encoders, Type B

Video Encoders, Type B, with rack mounting hardware are measured for payment by the number actually installed, complete, functional and accepted.

B. Video Encoders, Type C

Video Encoders, Type C, with rack mounting hardware are measured for payment by the number actually installed, complete, functional and accepted.

C. Video Decoders, Type B:

Video Decoders, Type B, with rack mounting hardware are measured for payment by the number actually installed, complete, functional and accepted.

D. Video Decoders, Type C:

Video Decoders, Type C, with rack mounting hardware are measured for payment by the number actually installed, complete, functional and accepted.

E. Video Decoders, Type D

Video Decoders, Type D, with rack mounting hardware are measured for payment by the number actually installed, complete, functional and accepted.

F. Video Decoders, Type E:

Video Decoders, Type E, with rack mounting hardware are measured for payment by the number actually installed, complete, functional and accepted.

936.4.03 Testing

Testing as described in section 936.3.06 is considered incidental to the cost of the camera systems and installation and shall not be paid for separately.

936.4.04 Training

Training is measured as a lump sum for all supplies, equipment, materials, handouts, travel, and subsistence necessary to conduct the training. **All provided equipment shall become property of the Department.**

936.4.05 Limits

Not applicable

936.5 Payment

936.5.01 CCTV System

CCTV systems of the Type specified in the Plans are paid for at the Contract Unit Price. Payment is full compensation for furnishing and installing or delivering the CCTV system.

Payment for CCTV systems is made under:

Item No. 936	CCTV System, Type ____	Per each
Item No. 936	CCTV System, Type B, Retrofit Assembly	Per each
Item No. 936	CCTV System, Type ____, Retrofit Assembly (Furnish Only)	Per each
Item No. 936	CCTV Camera lowering system	Per each
Item No. 936	Video Encoder, Type ____	Per each
Item No. 936	Video Decoder, Type ____	Per each

936.5.02 Training

The Department will pay twenty-five (25%) of the total contract bid amount for training upon approval of the Training Plan. The Department will pay the remaining seventy-five (75%) after completion of all training as described in Subsection 936.3.08. The total sum of all payments cannot exceed the original contract amount for this item.

Payment for training is made under:

Item No. 936	Training	Lump Sum
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936.5.03 Adjustments

Not applicable

Section 937—Detection Systems

937.1 General Description

This work includes the procurement and installation of a detection system as shown in the plans. Ensure the detection system is capable of traffic data collection meeting the general and specific requirements of this specification. Ensure the firmware and software furnished and installed as part of an Intelligent Transportation System (ITS) or traffic signal project are the most current and approved releases or versions, unless otherwise requested by the Department. Provide all equipment, materials, and work in accordance with all manufacturers' recommendations. All equipment, cables, and hardware must be part of an engineered system that is designed by the manufacturer to fully interoperate with all other system components.

A. Video Detection System (VDS)

Provide an IP/Ethernet video detection system which provides presence detection, vehicle counts, roadway occupancy, vehicle classification, and speed information to the Department's central ITS management software. The video detection system shall be able to provide a minimum of three programmable vehicle classifications. The video detection system shall be able to detect in both high speed freeway and intersection presence modes. The video detection system includes, but is not limited to, camera image sensor(s), including the detector housing, mounting hardware, an application programming interface (API) and protocol for system communications, a video detection system processor, central and local system management software, cabling between the detector and the cabinet, surge suppressors, terminations, output expansion modules which mount in the traffic signal controller cabinet input files, vertical conduit, weather heads and related equipment. The video detection system processors shall communicate through an Ethernet interface and TCP/IP (transmission control protocol/Internet protocol) connection to multiple Transportation Management Center (TMC) computers. The detection video shall be encoded within the VDS processor to MPEG4 digital video format and be able to be viewed at the TMC without the use of external encoders.

B. Microwave Vehicle Detection System (MVDS) – ITS Applications

Provide a high resolution microwave radar detection system which provides presence detection, vehicle counts, classification, occupancy, and speed information to the Department's central ITS management software. The microwave radar detection system includes, but is not limited to, microwave/ radar detectors, including detector housing, mounting hardware, an application programming interface (API) and protocol for system communications, system management software, cabling between the microwave detector(s) and the cabinet, surge suppressors, terminations, and related equipment. The high resolution Microwave Vehicle Detection System shall be able to emulate single or dual zone loop detectors and be able to detect a minimum of 10 lanes with a range of up to 250 feet away. These microwave detection systems are typically used for gathering near real-time information about the flow of traffic on freeways, highways, or other designated roadway types. The MVDS shall be provided with all necessary cabling, surge protection devices and modules for local serial and IP/Ethernet communications.

C. Wireless Magnetometer Vehicle Detection (WMVD)

Provide a wireless in-pavement magnetometer system for use in both freeway and intersection applications. The detection system shall provide accurate vehicle count, occupancy and speed information, as well as presence/stop bar applications, as needed. The battery-powered wireless sensor shall consist of a magnetometer capable of low-power radio communications to a roadside transceiver, packaged in a small, hardened plastic case, suitable for in-pavement mounting. The sensors shall detect changes in the earth's magnetic field to determine the presence or absence of vehicles, relative to the detection zone. Detection 'events' are transmitted via wireless radio communications to a wired access point connected to the control cabinet. The wired access point shall utilize IP/Ethernet communication. The system includes, but is not limited to battery operated wireless sensors, battery operated wireless repeaters, antennas, wired access points with respective radios, mounting hardware, cabling, surge protection devices, jumper cables and all items necessary for a complete WMVD installation

D. Short-Range Radio Device Detection System

Provide a Short-Range Radio Device detection system in which a roadside monitoring unit continually and passively listens for Short-Range Radio enabled devices that broadcast their BDADDR (or BADDR), also referred to as the MAC address. The addresses shall be passively collected in order to get vehicle probe data for use in determining travel time along a route. These devices shall not have the ability to correlate a MAC address with personal information, such as subscriber names and/or vehicle ownership information. This type of detection system shall not be used to collect highly accurate volume and occupancy of a roadway, but rather collect a sampling of vehicles in order to derive approximate speeds and travel time for a corridor. Provide separate, powered and surge protected enclosures for Short-Range Radio Device modules so that they may be installed in various cabinet types. All modules shall utilize IP/Ethernet communications, or cell modem by Type. The system includes, but is not limited to the Short-Range Radio Device processor, antenna, power supplies, mounting hardware, cabling, surge protection devices, jumper cables and all items necessary for a complete installation.

E. Microwave Vehicle Detection System (MVDS) – Intersection Applications

Provide a high resolution microwave radar detection system which provides presence detection, vehicle counts, classification, occupancy, and speed information. The microwave radar detection system includes, but is not limited to, microwave / radar detectors, including detector housing, mounting hardware, an application programming interface (API) and protocol for system communications, system management software, cabling between the microwave detector(s) and the cabinet, surge suppressors, terminations, and related equipment. The high resolution Microwave Vehicle Detection System shall be able to emulate single or dual zone loop detectors and be able to detect a minimum of 8 lanes with a minimum range of 100 feet. These microwave detection systems are typically used for detecting vehicles at signalized intersections and inputting service calls to the signal controller. The MVDS shall be provided with all necessary cabling, surge protection devices and modules for local serial and IP/Ethernet communications.

937.1.01 Definitions

General Provisions 101 through 150

937.1.02 Related References

A. Standard Specifications

Section 150 – Traffic Control

Section 639 – Strain Poles for Overhead Sign and Signal Assemblies

Section 647 – Traffic Signal Installation

Section 922 – Electrical Wire and Cable

Section 925 – Traffic Signal Equipment

Section 939 – Communication and Electronics Equipment

Section 940 – NaviGator Advanced Transportation Management System Integration

B. Referenced Documents

American National Standards Institute (ANSI)

American Society of Testing and Materials (ASTM)

EIA-170A

Electronic Industries Association (EIA) – 170A

FCC Part 15, Subparts J and B

National Electric Code (NEC) 210-19a., FPN No. 4

National Electrical Manufacturers Association (NEMA) TS1-1989 (R1994, R2000, R2005), Section 2.1.5.2, Section 2.1.12

NEMA TS-1-1989 (R1994, R2000, R2005)

NEMA TS2-2003 Type 2, Type 170 and Type 179 Standards

NEMA 250 Type 4 enclosure standards

Underwriter's Laboratory Incorporated (UL) Submittals

937.1.03 Submittals

Use only equipment and components that meet the requirements of these minimum specifications and the Department's Qualified Products List (QPL).

Provide submittal data for all equipment, materials, test procedures, and routine maintenance procedures required for these items as required in these Specifications.

For training, submit to the Engineer for consideration and approval a training schedule and all training materials within 60 calendar days from the NTP.

For each applicable vehicle detection system, submit to the Engineer for approval, two (2) hard copies and one (1) electronic copy of the manufacturer's descriptive literature (catalog cuts), technical data, operational documentation, service and maintenance documentation and all other materials required within these specifications. Electronic documents shall be placed on a CD as Adobe® pdf documents and delivered to the Engineer.

Provide as-built documentation of all detector installations after the completion of acceptance testing.

937.2 Materials

937.2.01 Video Detection System

Use a video camera sensor that is compatible with the video detection system processor and meets the following technical and functional requirements:

A. Requirements

1. Video Camera Sensor Type A

Furnish and install a video camera sensor that is compatible with both freeway and arterial video applications, and compatible with the required detection processor type. Send a video signal from the video camera sensor to the processor, using high resolution, video camera sensors as the primary video source for real-time vehicle detection. Utilize high-sensitivity optics in the video camera sensor to compensate for variations in lighting conditions, including blooming at night caused by headlights and minor vibration caused by wind. Include a heater at the front of the enclosure, or alternate method, to prevent the formation of ice and condensation in cold weather. Ensure that the heater does not interfere with the operation of the video camera sensor electronics, or cause interference with the video signal, where applicable. As a minimum, meet the following requirements for each video camera sensor assembly installation:

- a. Use a 1/4" to 1" color interline or frame transfer charge coupled device (CCD) or CMOS sensor.
- b. Signal to Noise Ratio shall be greater than 47 dB
- c. If using analog video, the video standard should be compliant with National Television System Committee (NTSC) Standard, RS-170A Compliant (available as EIA-170A specification)
- d. If using digital video, the video standard should be compliant with ATSC Standard H.264
- e. Provide a lens with a minimum 18X digital or optical zoom. Zoom and camera controls shall be over the camera coaxial video connector
- f. A minimum resolution of 380 Horizontal Television Lines (TVL), 350 Vertical TVL

- g. For Electromagnetic interference, ensure compliance with FCC Part 15, Subpart J, Class A device requirements, which apply to the video camera sensor and associated connected equipment in their installed condition
- h. Power the video camera sensors with 115 VAC \pm 10%, 60 Hz nominal \pm 3 Hz. Size the power conductors from the power source to the camera input so that no more than a 3% voltage drop is experienced (NEC 210-19 a., FPN No. 4). Include a provision at the rear of the camera enclosure for a waterproof connection of power and video signal cables over a single weather-tight MilSpec connector. Provide power from the cabinet power source through a surge suppressor and then to the video camera sensor.
- i. The Video camera sensor enclosure shall be installed in a light colored enclosure to limit solar heating. Meet NEMA 250 Type 4 enclosure standards for the enclosure and seal the enclosure to prevent sand, dirt, dust, salt and water from entering. Affix a sun shield visor to the front of the enclosure which is sufficiently adjustable to divert water away from the video camera sensor lens and also prevent direct sunlight from entering the iris when mounted in its installed location.
- j. Provide a single run of non-spliced outdoor-rated power and coaxial video cabling from the sensor enclosure to the cabinet in accordance with the manufacturer's recommendations. Interruptions in cable runs shall only be allowable for interfacing necessary surge protection devices. All connectors shall be professionally sealed to manufacturer recommendations.
- k. Environmental: Ensure that temperature and humidity limits of the sensor adhere to NEMA TS2-2003 requirements.
- l. Shock and Vibration: Ensure that shock and vibration of the sensor adheres to NEMA TS2-2003 requirements

2. Video Camera Sensor Type B

Furnish and install a thermal video camera sensor that is compatible with both freeway and arterial video applications, and compatible with the required detection processor type. Send a thermal video image from the thermal video camera sensor to the processor for real-time vehicle detection. Utilize thermal imaging to compensate for variations in lighting conditions, including blooming at night caused by headlights, rain and ice glare, and daytime cloud and sun position shadowing where a normal video camera sensor may not function as intended. Include a heater, or alternate method, to prevent the formation of ice and condensation in cold weather. Ensure that the heater does not interfere with the operation of the video camera sensor electronics, or cause interference with the thermal video signal. As a minimum, meet the following requirements for each thermal video camera sensor assembly installation:

- a. Use a long-life, uncooled Vanadium Oxide (VOx) Microbolometer for the detector sensor, with a spectral range of 7.5 – 13.5 μ m.
- b. If using analog video, the video standard should be compliant with NTSC Standard and shall have a minimum NTSC array format of 320 x 240, with a 76,800 effective resolution
- c. If using digital video, the video standard should be compliant with ATSC Standard H.264
- d. For Electromagnetic interference, ensure compliance with FCC Part 15, Subpart B, Class B device requirements.
- e. Power: Input voltage shall be 90 – 240 VAC single phase, with standard operating voltage at 110 VAC. Power consumption shall be 1.7 Watts nominal at 110 VAC with a maximum of 18 Watts.
- f. The thermal video camera sensor enclosure shall be installed in a light colored enclosure to limit solar heating and prolong equipment life.
- g. Provide a single run of non-spliced outdoor-rated power and coaxial video cabling from the sensor enclosure to the cabinet in accordance with the manufacturer's recommendations. Interruptions in cable runs shall only be allowable for interfacing necessary surge protection devices. All connectors shall be professionally sealed to manufacturer recommendations.
- h. Environmental: -50° C to + 75° C (-58° F to 167° F) operating ambient temperature rated, in 0% - 95% relative humidity, with an IP66 rating.

3. Video Detection System Processor

Freeway Cabinet Mounting

The IP addressable, MPEG4 encoded video detection system processor shall be either shelf or rack mountable in a standard 19-inch rack assembly space conforming to Standard CEA-310, 2005, latest version/addendum. If the video processor is shelf mounted, the Contractor shall provide the shelf and the processor unit housing for each processor type. If the video detection system requires a 19" rack with powered backplane, the contractor shall provide the 19" rack and attach all power and communications cables according to manufacturer specifications. The video detection system processor shall be designed for mounting in an enclosed cabinet and/or Hub building without blower fans and mounting without insulation from other electronic devices such as power supplies, communications equipment, etc. The video detection system shall meet NEMA TS-2 temperature requirements.

Power the video detection system processor by 120 VAC, 60 Hz, single phase. If a transformer is required for a 12 or 24 VDC power requirement, the Contractor shall supply the transformer and/or enclosure and size it appropriately for the installation. Size power conductors from the power source for the video detection system processor input so that no more than a 3% voltage drop is experienced (NEC 210-19 a., FPN No. 4). The video detection system processor shall have transient protection that meets the requirements of NEMA TS1-1989 (R1994, R2000, R2005) and NEMA TS2-2003 standards.

- Video Detection System Processor, Type A

Provide one (1) video inputs on the video detection system processor such that signals from one video camera sensor or other synchronous or non-synchronous video source can be processed in real time. Use BNC connectors on the processor for all video inputs. Use a BNC connector or RCA connector on the front of the video detection system processor for video output.

- Video Detection System Processor, Type B

Provide at least two (2) video inputs on the video detection system processor such that signals from up to two (2) video camera sensors or other synchronous or non-synchronous video sources can be processed in real time in one cabinet. Use BNC connectors on the back of the video detection system processor for all video inputs. Use a BNC connector on the front or back of the video detection system processor for video output.

- Video Detection System Processor, Type C

Provide at least four (4) video inputs on the video detection system processor such that signals from up to four (4) video camera sensors or other synchronous or non-synchronous video sources can be processed in real time in one cabinet. Use BNC connectors on the back of the video detection system processor for all video inputs. Use a BNC connector on the front or back of the video detection system processor for video output.

4. Signal or Ramp Meter Cabinet Mounting

Provide an IP addressable processor module, which performs video image processing and MPEG4 encoding, that completely fits within the loop detector slots of the traffic signal or ramp meter controller cabinet input file and that provides a standard relay closure detector input to the controller. Provide from one to four detector outputs through the processor module which communicate through the edge card connector. Use a module that is not wider than two standard input file slots. Include detection indicators on the front panel of the processor module for each channel of detection provided through that module to indicate detector output in real time when the system is operational. Include a BNC connector with gold plated center pin or RCA connector on the front panel for video output to a Monitoring device, and include a RJ-45 Ethernet port connector on the front panel to connect and communicate the Programming Device.

Provide power to the processor modules through the signal or ramp cabinet detector input file, or the Output Expansion Module.

- Video Detection System Processor, Type D

Provide one (1) video inputs on the video detection system processor such that signals from one video camera sensor or other synchronous or non-synchronous video source can be processed in real time. Use BNC connectors on the processor for all video inputs. Use a BNC connector or RCA connector on the front of the video detection system processor for video output.

- Video Detection System Processor, Type E

Provide at least two (2) video inputs on the video detection system processor such that signals from up to two (2) video camera sensors or other synchronous or non-synchronous video sources can be processed in real time

in one cabinet input file. Use BNC connectors on the back of the video detection system processor for all video inputs. Use a BNC connector on the front or back of the video detection system processor for video output.

- Video Detection System Processor, Type F

Provide at least four (4) video inputs on the video detection system processor such that signals from up to four (4) video camera sensors or other synchronous or non-synchronous video sources can be processed in real time in one cabinet input file. Use BNC connectors on the back of the video detection system processor for all video inputs. Use a BNC connector on the front or back of the video detection system processor for video output.

- Environmental Requirements (All Types)

Provide a video detection system processor that operates reliably in a typical roadside traffic cabinet environment. Provide internal cabinet equipment and a video detection system processor that meet the environmental requirements of NEMA TS1-1989 (R1994, R2000, R2005) and NEMA TS2 standards.

- Operating ambient temperature range: Ensure that temperature limits adhere to NEMA TS2-2003 requirements. Additionally, include a heater to prevent the formation of ice and condensation in cold weather. Do not allow the heater to interfere with the operation of the video camera sensor electronics, or cause interference with the video signal.
- Humidity range: Ensure that humidity limits adhere to NEMA TS2-2003 requirements.

B. Functional Requirements for Video Detection Systems (all Types)

This section defines the minimally required functional aspects of the system as well as the required accuracy levels. It also outlines the testing process that will be used to determine whether a proposed video detection system product meets these specifications.

1. Ensure that Video Detection Systems provides vehicle presence, speeds, vehicle counts and roadway occupancies on a lane-by-lane basis. Video detection systems operating in a traffic signal installation shall not be required to provide occupancy or classification data. Verify that the system can, at a minimum, emulate the output of a pair of 6 ft. by 6 ft. in-pavement loops spaced 16 ft. apart. Ensure that the Video Detection Processor is capable of providing a minimum 24 detection zones with one video camera sensor. Verify that the system responds with the accumulated traffic data as collected since the last request.
2. Verify that the detection system is IP-addressable and that all communication addresses are user programmable. Ensure the setup program assigns an IP address to the detection processor. Ensure that configuration to the system are either in serial format using an Electronic Industries Alliance (EIA) standard EIE-232 communication or an Internet Protocol (IP) interface as approved by GDOT's Information Technology group.
3. Verify that the traffic data collected by the Video Detection System and the system configuration is stored within internal non-volatile memory within the video detection system processor. Perform software updates through an Ethernet, serial, or USB port. Verify that data can be retrieved from the system either locally or via requests from computers at the central Transportation Management Center (TMC) over the communications network.
4. Ensure the video detection system processor front panel includes a visual display of the status of each video input. Indicators shall display, at a minimum, the status of video detection system processor communications, the status of the video detection system processor, the status of communications, and whether or not each video camera sensor is actively detecting. The Video Processor shall allow a remote user with a standard web browser to gain remote access, collect data, control, and configure the VDS.
5. Ensure the Video Detection System includes computer software, which enables the user to program, calibrate, operate and view current status of all system features using a laptop computer, or network-connected workstation at the central TMC. Ensure the system allows the user to view live MPEG4 video from the image sensor with the programmed detectors overlaying the image. Ensure individual vehicle actuations can be viewed while observing the live MPEG4 encoded video.
6. Ensure the Video Detection System configuration data can be uploaded and saved to a laptop or TMC workstation computer for later re-loading to the video detection processor if necessary.
7. Ensure that the system offers an open Application Programming Interface (API) and software development kit (SDK) for GDOT developers and their consultants to integrate the Video Detection System with Central Software or other third-party software and systems. Furnish needed software licenses for the system.
8. Ensure the system user can use a laptop to reprogram, calibrate, adjust or alter any previously defined detector configurations in the field and also reprogram any detector configurations over the network or from a TMC workstation.

9. Provide software that can communicate concurrently between multiple users and multiple video detection processors on the same network without any interruption or conflict with the normal polling cycle.

C. Additional Functional Requirements for Signal and Ramp Meter Video Detection Systems (Type D, E, F)

1. System Hardware: Provide a detection system that does not require any equipment external to the traffic signal/ramp meter controller cabinet input file (excluding the video camera sensor, video camera sensor power connection, circuit breakers and surge protection for video or data). Mount the processor and expansion modules in the traffic signal/ramp meter controller cabinet input files, using the edge card connector to obtain power and provide contact closure outputs. Rewiring of the backplane or any other cabinet panel for the system is not permitted except for power and grounding for the interface panel, wiring from the video camera sensor to the loop detector panel for the video signal and wiring to obtain power for the video camera sensor.
2. Provide a system capable of providing a minimum of eight detector outputs per video camera sensor. Provide all detector outputs through edge card connectors of the processor module and output expansion module(s). Rewiring external to the edge connectors is not permitted for obtaining a minimum of eight outputs for one video camera sensor.
3. System Software System Processing Software: On the processor module that mounts in the traffic signal/ramp meter controller cabinet input file, include the software that processes the video camera sensor signals and converts the signals into detector outputs. Detect either approaching or receding vehicles in multiple lanes within the field of view (FOV) of each video camera sensor. Provide the capability of detecting vehicles in up to 24 detection zones per video camera sensor with the detection system. Allow the detection zones to be combined to form one output.
4. Detection Compensation: Provide the capability for the processor to compensate for camera movement attributable to temperature effects, wind shifting, pole sway, pole expansion, or vibration.
5. System Configuration Software: On the processor module, include the configuration software to program the detection system, including the detection zones.
6. On a monitoring device, display the detection zones superimposed on the video camera sensor's images. Provide the capability to create detection zones of varying size and shape to allow best coverage of the viewable roadway lanes and ramps. Provide the capability to save the detection zone format on the processor module card once drawn for a particular video camera sensor image. Provide the following capabilities for the user to view the currently active detector zone format of the MPEG4 encoded processor module via a monitoring device:
7. Confirmation: When viewing vehicle actuations in real time on the monitoring device, indicate the passage or presence of each vehicle detected by each detection zone by changing the color or intensity of that particular zone.
8. Detection During Reconfiguration: Provide the capability for the detection system to continue detecting vehicles on all existing zones during reconfiguration, except on the zone that is being reconfigured.
9. I-VDS_n designation: I-VDS_n refers to all of the specific VDS components necessary for operation and detection on one approach leg of an intersection. The "n" denotes the approach's through-movement controller phase in the nomenclature of a typical 8-phase dual-ring intersection operation (e.g., I-VDS₂, I-VDS₄, I-VDS₆, I-VDS₈) when four video camera sensors are installed. If more than four video camera sensors are installed, the "n" denotes the controller phase being detected in the nomenclature of a typical 8-phase dual ring intersection operation. I-VDS_n is also used as a prefix to identify the individual VDS components of the "n" approach as follows:
 - I-VDS_nVCS: the video camera sensor for approach "n"
 - I-VDS_nCC: the coaxial cable from the video camera to the controller cabinet for approach "n"
 - I-VDS_nPC: the video camera sensor power cable from the video camera to the controller cabinet for approach "n"
 - I-VDS_nCSS: the coaxial cable surge suppressor in the controller cabinet for approach "n"
 - I-VDS_nCJ: the coaxial jumper cable from the coaxial surge suppressor in the controller cabinet to the processor module or detector panel for approach "n"
 - I-VDS_nPM: the processor module for approach "n", where a Processor Module, Type A is installed
 - I-VDS_{pn/sn}PM: the processor module for approach "pn" and "sn", where "pn" is the primary approach and "sn" is the secondary approach, where a Processor Module, Type B is installed.
 - Occupancy: individual lane occupancy measured in percent of time
10. Ramp Meter Controller Cabinet Input File: A Ramp Meter Controller Cabinet Input File is a chassis within a traffic signal cabinet rack that has slots where a detector card provides detector output to the traffic signal controller

through its edge card connectors. The backplane connector pin output of the edge connectors conforms to Georgia traffic signal controller cabinet standards for the cabinet type specified in the plans.

11. I-VDS_{nnn}: I-VDS_{nnn} refers to all of the specific VDS components necessary for operation and detection related to ramp metering installations based on direction, type of detection and lane assignments. The first “n” denotes the approach direction (north, south, east or west) and the second “n” denotes the type of detection, P=Passage Detection Zones, D=Demand Detection Zones, Q=Queuing Detection Zones, ML=Mainline Detection Zones, the third “n” denotes the lane assignment (lane 1=L01, lane 2=L02, lane =L03, lane= L04), the (e.g., I-VDS_nPL01, I-VDS_sDL02, I-VDS_eQL03, I-VDS_wMLAL04). The typical ramp meter layout is shown below:

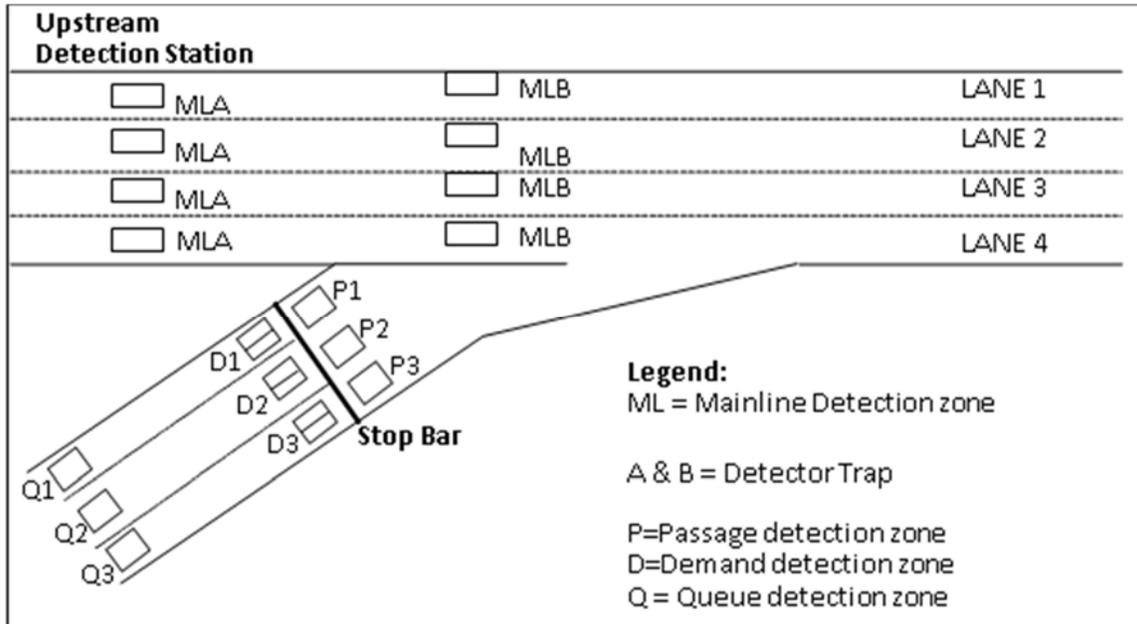


Figure 1: Typical Ramp Meter Layout

Lane numbering shall begin at the median for mainline travel lanes. Lane numbering for ramp meter lanes shall begin with the lane adjacent to the mainline travel lanes,

I-VDS is also used as a prefix to identify the individual I-VDS components used for signal and freeway ramp metering as follows:

- I-VDS_{nnn}VCS: the video camera sensor for “nnn” direction, type of detection and lane assignment
- I-VDS_{nnn}CC: the coaxial cable from the video camera to the controller cabinet for approach “nnn” direction, type of detection and lane assignment
- I-VDS_{nnn}PC: the video camera sensor power cable from the video camera to the controller cabinet for approach “nnn” direction, type of detection and lane assignment
- I-VDS_{nnn}CSS: the coaxial cable surge suppressor in the controller cabinet for approach “nnn” direction, type of detection and lane assignment
- I-VDS_{nnn}CJ: the coaxial jumper cable from the coaxial surge suppressor in the controller cabinet to the processor module or detector panel for approach “nnn” direction, type of detection and lane assignment
- I-VDS_{nnn}PM: the processor module for approach “nnn” direction, type of detection and lane assignment

D. Accuracy Requirements for Video Detection Systems

Provide a Video Detection System that meets the below minimum accuracy requirements for both daytime and night time conditions:

1. For volume (vehicle counts): 85% (no more than +/- 15% missed actuations).
2. For speed measurement: 85% (no more than +/- 15% error in speed calculation)
3. For occupancy measurement: 85% (no more than +/- 15% missed actuations)

4. For presence detection: 85% (no more than +/- 15% error in missed actuations)

E. Testing

Vendors are required to submit an independent test evaluation report from a third party which verifies the accuracies stated within their specifications.

Develop and submit plans for post-installation testing to the Engineer for consideration and approval. Ensure the plans test all functional requirements outlined in Section 937.2.01, and the accuracy requirements stipulated in Section 937.2.01 D. Provide the Engineer with Application Protocol Interface (API) documentation and Software Development Kit (SDK) for the video detection system, as requested by the Department. GDOT will have 30 days from receipt of the API and SDK to make a determination if it can be integrated. If the device cannot be integrated, the Engineer will give notice that the Contractor must submit a device that can be integrated into the central system software.

1. Post Installation Test Requirements

Utilize the following test procedures after the video detection system has been installed in its entirety as shown on the Plans. Commence no post-installation testing until all video detection systems in the project have been configured and/or calibrated to gather speed, volume, occupancy and/or presence detection, and programmed to communicate on the GDOT network. Including the accuracy testing requirements, at a minimum, provide the following on the test plan to be submitted and approved by the Engineer:

2. Inspect all vehicle detection system field components to ensure proper installation and cable termination.
3. Verify that field construction has been completed as specified in the plans.
4. Inspect the quality and tightness of ground and surge protector connections.
5. Check power supply voltage and outputs and ensure device connections are as specified in the Plans.
6. Verify that the installation of cables and connections between all detectors and field cabinets are as specified in the Plans
7. Demonstrate that each Video Detection System is fully operational and gathering the required data types at the specified interval. Perform this test from the hub building through which the detection system is connected.
8. Upon satisfactory completion of step f, GDOT will add the new video detection system(s) into the central system.

937.2.02 Microwave Vehicle Detection System (MVDS)

A. Requirements

1. Microwave Detector Type A

Provide a microwave detection system for ITS installations that meets the following minimum requirements:

- a. **Microwave Transmission:** The microwave radar detector shall transmit on a frequency band of 24 (twenty-four) GHz or another approved spectral band. It shall comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules or the appropriate Spectrum Management Authority. The Microwave Unit shall not interfere with any known equipment.

- b. **Area of Coverage**

The Microwave Unit's field of view shall cover an area defined by an oval shaped beam and its maximum detection range shall be as follows:

Elevation Beam Width	50 degrees or more
Azimuth Beam Width	12 degrees or less
Range	up to 250 feet

- c. **Detection Zones**

The minimum number of detection zones defined shall be no less than ten (10) for side-fired configuration.

- d. **Capabilities**

Ensure that Microwave Detection Systems Type A proposed for use provide vehicle presence, classification, speeds, vehicle counts and roadway occupancies on a lane-by-lane basis at a user definable reporting period and can detect a minimum of 10 detection zones where the farthest lane at ideal mounting height can detect at a maximum distance of 250 feet.

The Microwave Unit shall be a presence detector. It shall be suitable for mounting on roadside poles or on overhead structures at a mounting height determined by the manufacturer, to provide the following:

- Presence indication of vehicles in its detection zones.
- Traffic data, periodically accumulated over user defined time intervals in a 10 to 600 sec range, shall be transmitted via serial RS-485 communications lines to a serial port on the terminal server.
- Traffic data shall be available simultaneously with detection zone contact closures and serial communications. Supply all modules as necessary for simultaneous communications.
- Vehicle classification by length in a minimum of 3 user defined classes.
- MVDS shall allow the user to define the contents of transmitted data.
- Furnish the unit with the required software for data collection, processing, configuration and set-up, and data logging and retrieval. An operator shall be able to use the software to set detector count periods, sensitivities, and other operational features and parameters. The software must be capable of providing both manual and automatic setup and calibration.

Side-fired configuration data shall include the following in each of up to ten (10) detection zones (lanes):

- Volume
- Lane occupancy
- Average speed

e. Environmental Conditions and Protection

Except as stated otherwise herein, the equipment shall meet all its specified requirements during and after subjecting to any combination of the following:

- Temperature and humidity limits per NEMA TS2-2003 requirements
- Power surge of ± 1 kV (rise time = 1.2 μ sec, hold = 50 μ sec) applied in differential mode to all lines, power and output, as defined by IEC 1000-4-5 and EN 61000-4-5 standards or 300v TS2
- The microwave radar detector shall be resistant to vibration in accordance with IEC 68-2-30 (test Fc), NEMA TS-1 (Section 2.1.12), or approved equivalent
- The microwave detector shall be resistant to shock in accordance with IEC 68-2-27 (test a), NEMA TS-1 (Section 2.1.13), or approved equivalent

f. Mechanical

The microwave radar detector shall be enclosed in a rugged weather proof box and sealed to protect the unit from wind up to 90 mph, dust and airborne particles, and exposure to moisture (NEMA Type 3R or 4x enclosure).

The mounting assembly shall have all coated steel, stainless steel, or aluminum construction, and shall support a load of 20 pounds. The mounting assembly shall incorporate an approved mechanism that can be tilted in both axes and then locked into place, to provide the optimum area of coverage.

g. Electrical

The MVDS unit shall be operable from 12 - 24 VDC. Power supply shall be obtained from the MVDS communications wiring module in the device cabinet. Alternative power sources and adapters shall be submitted and approved by the Engineer.

The MVDS unit shall include Power Management features, allowing remote shutdown or cyclical shutdown of the unit.

h. Cables

Connection between the MVDS and the cabinet equipment shall be provided by a single MVDS unit harness cable that is MS-connector terminated at the MVDS detector and terminated to the MVDS communications wiring

module in the equipment cabinets. No splices are permitted in the cable. The cable shall at a minimum provide power and the RS-485 serial data interface to the MVDS unit.

The MS connector pins must be crimped to the cable conductors and assembled and tested by the manufacturer prior to installation and pulling of cable on site. RS-485 signal ground shall be provided by the shield drain wire, an additional conductor, or an additional shielded pair, in accordance with the MVDS unit manufacturer's recommendations. Twisted pairs shall be identified by separate insulation colors. Communications pairs shall be individually or commonly shielded. Low voltage power conductors shall not be shielded in common with the communications pairs.

i. Electrical Isolation and Surge Protection

All power lines, contact closures and the serial port shall be surge protected within the unit. Contact closures and the serial port shall be isolated. Ensure that the surge protection of all cables and connections meets the minimum requirements of Section 925.2.02 A, part 14, Surge Protection.

j. Data Interface

- Data communications shall be full duplex asynchronous, configurable as:
- Opto-isolated RS-485 port at rates from 9600 up to 115200 bits per second
- Separate, local control RS-232 or RS-485 ports
- Serial data format shall be standard binary NRZ 8 bits data, 1 stop bit, No parity
- Both point-to-point and multi-dropped configurations shall be supported.

2. Microwave Detector Type B

Provide a microwave detection system for traffic signal installations that meets the following minimum requirements:

- a. Microwave Transmission: The microwave radar detector shall transmit on a frequency band of 24 (twenty four) GHz or another approved spectral band. It shall comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules or the appropriate Spectrum Management Authority. The Microwave Unit shall not interfere with any known equipment.

b. Area of Coverage

The Microwave Unit's field of view shall cover an area defined by an oval shaped beam and its maximum detection range shall meet manufacturer's specification and provide accurate detection to the controller.

c. Detection Zones

The minimum number of detection zones defined shall be no less than eight (8).

d. Capabilities

Ensure that Microwave Detection Systems Type B proposed for use provides vehicle presence on a lane-by-lane basis and can detect a minimum of 8 detection zones where the farthest lane at ideal mounting height can detect at a minimum distance of 100 feet.

The Microwave Unit shall be a presence detector. It shall be suitable for mounting on roadside poles or on overhead structures at a mounting height determined by the manufacturer, to provide the following:

- Presence indication of vehicles in its detection zones.
- Traffic data shall be transmitted to the controller. Supply all modules as necessary for simultaneous communications.
- MVDS shall allow the user to define the contents of transmitted data.
- Furnish the unit with the required software for data collection, processing, configuration and set-up, and data logging and retrieval. An operator shall be able to use the software to set detector count periods, sensitivities, and other operational features and parameters. The software must be capable of providing both manual and automatic setup and calibration.

- Volume
- Travel direction
- Per vehicle speed and direction (in forward looking configuration)

e. Environmental Conditions and Protection

Except as stated otherwise herein, the equipment shall meet all its specified requirements during and after subjecting to any combination of the following:

- Temperature and humidity limits per NEMA TS2-2003 requirements
- Power surge of $\pm 1\text{kV}$ (rise time = 1.2 μsec , hold = 50 μsec) applied in differential mode to all lines, power and output, as defined by IEC 1000-4-5 and EN 61000-4-5 standards or 300v TS2
- The microwave radar detector shall be resistant to vibration in accordance with IEC 68-2-30 (test Fc), NEMA TS-1 (Section 2.1.12), or approved equivalent
- The microwave detector shall be resistant to shock in accordance with IEC 68-2-27 (test a), NEMA TS-1 (Section 2.1.13), or approved equivalent

f. Mechanical

The microwave radar detector shall be enclosed in a rugged weather proof box and sealed to protect the unit from wind up to 90 mph, dust and airborne particles, and exposure to moisture (NEMA Type 3R or 4x enclosure).

The mounting assembly shall have all coated steel, stainless steel, or aluminum construction, and shall support a load of 20 pounds. The mounting assembly shall incorporate an approved mechanism that can be tilted in both axes and then locked into place, to provide the optimum area of coverage.

g. Electrical

The MVDS unit shall be operable from 12 - 24 VDC. Power supply shall be obtained from the MVDS communications wiring module in the device cabinet. Alternative power sources and adapters shall be submitted and approved by the Engineer.

The MVDS unit shall include Power Management features, allowing remote shutdown or cyclical shutdown of the unit.

h. Cables

Connection between the MVDS and the cabinet equipment shall be provided by a single MVDS unit harness cable that is MS-connector terminated at the MVDS detector and terminated to the MVDS communications wiring module in the equipment cabinets. No splices are permitted in the cable. The cable shall at a minimum provide power and the RS-485 serial data interface to the MVDS unit.

The MS connector pins must be crimped to the cable conductors and assembled and tested by the manufacturer prior to installation and pulling of cable on site. RS-485 signal ground shall be provided by the shield drain wire, an additional conductor, or an additional shielded pair, in accordance with the MVDS unit manufacturer's recommendations. Twisted pairs shall be identified by separate insulation colors. Communications pairs shall be individually or commonly shielded. Low voltage power conductors shall not be shielded in common with the communications pairs.

i. Electrical Isolation and Surge Protection

All power lines, contact closures and the serial port shall be surge protected within the unit. Contact closures and the serial port shall be isolated. Ensure that the surge protection of all cables and connections meets the minimum requirements of Section 925.2.02 A, part 14, Surge Protection.

j. Data Interface

Data communications shall be full duplex asynchronous, configurable as:

- Opto-isolated RS-485 port at rates from 9600 up to 115200 bits per second
- Separate, local control RS-232 OR rs-485 ports

- Serial data format shall be standard binary NRZ 8 bits data, 1 stop bit, No parity
- Both point-to-point and multi-dropped configurations shall be supported.

B. Functional Requirements for Microwave Detection Systems Type A and B

This section defines the minimally required functional aspects of the microwave detection system as well as the required accuracy levels. It also outlines the testing process that will be used to determine whether a proposed microwave detection system product meets these specifications.

1. Verify that the traffic data collected by the Microwave Detection System is stored within internal non-volatile memory. Verify that data can be retrieved from the system either locally or via requests from computers at the central Transportation Management Center (TMC) over the communications network. Verify that the system configuration data and system software is also stored within internal non-volatile memory.
2. Ensure the Microwave Detection System includes computer software for the user to program, calibrate, operate and view current status of all system features using a laptop computer or network-connected workstation at the central TMC. Ensure the system allows the user to view live actuations from the microwave detector with the programmed detectors overlaying a representation of the roadway.
3. Ensure the Microwave Detection System configuration data can be uploaded and saved to a laptop or TMC workstation computer for later re-loading to the video detection processor if necessary. Ensure the system user can use a laptop or TMC workstation to reprogram, calibrate, adjust or alter any previously defined detector configurations. Ensure no periodic adjustments or fine-tuning is required except in the case of physical roadway changes such as lane-shifts, new construction or closures.
4. Ensure that the system offers an open Application Programming Interface (API) and software development kit (SDK) for GDOT developers and their consultants to integrate the Microwave Detection System with GDOT Central Software or other third-party software and systems. Furnish needed software licenses for the system.

C. Accuracy Requirements for Microwave Detection Systems

Provide a Microwave Detection System that meets the below minimum accuracy requirements for all conditions. Accuracy measurements for the testing shall be done with an appropriate sample size of vehicles, over a specific time period. Submit to the Engineer the Test plan for accuracy testing at the location that is site specific to the plans. The test plan shall take into account the roadway type (freeway, arterial), location (urban, rural), and traffic conditions in order to determine appropriate testing length and sample size. The following conditions shall be met for each sensor installed:

Measurement Accuracy

The following error levels shall be achievable and demonstrated during testing:

<u>Parameter (For Type A and B)</u>	<u>Error Percentage</u>
Presence	±5%
Time event	10ms
Input Voltage	±2%
<u>Parameter (For Type A)</u>	<u>Error Percentage</u>
Volume	±8%
Lane Occupancy	±10%
Average Speed	±10%
Length Classification limits	±10%

D. Testing

Develop and submit plans for post-installation testing to the Engineer for consideration and approval. Ensure the plans test all functional requirements outlined in Section 937.2.02 B and the accuracy requirements stipulated in Section 937.2.02 C. Provide the Engineer with Application Protocol Interface (API) documentation and Software Development

Kit (SDK) for the microwave detection system. GDOT will have 30 days from receipt of the API and SDK to make a determination if it can be integrated. If the device cannot be integrated, the Engineer will give notice that the Contractor must submit a device that can be integrated into the central system software.

1. Post-installation test requirements
2. Utilize the following test procedures after the microwave detection system has been installed in its entirety as shown on the Plans. Commence no post-installation testing until all microwave detection systems in the project have been configured and/or calibrated to gather speed, volume, classification, and occupancy and programmed to communicate on the GDOT network. Including the accuracy testing requirement, at a minimum, provide the following on the test plan to be submitted and approved by the Engineer.
3. Inspect all microwave detection system field components to ensure proper installation and cable termination.
4. Verify that field construction has been completed as specified in the plans.
5. Inspect the quality and tightness of ground and surge protector connections.
6. Check power supply voltage and outputs and ensure device connections are as specified in the Plans.
7. Verify that the installation of cables and connections between all detectors and field cabinets are as specified in the Plans and in accordance with the manufacturers' recommendations.
8. Demonstrate that each Microwave Detection System is fully operational and gathering the required data types at the specified interval. Perform this test from the hub building through which the detection system is connected.
9. Upon satisfactory completion of step f, GDOT will add the new microwave detection system(s) into the central system

937.2.03 Wireless Magnetometer Vehicle Detector System (WMVD)

This specification sets forth the minimum requirements for a system to detect vehicles on a roadway by using battery-powered magnetometer-type sensors that communicate their detection data by radio to a roadside communications hub before the data is relayed to a freeway cabinet, a local traffic controller cabinet, a central software system, and/or a data server as required by the application. The application of the WMVDS and equipment specified shall be as shown in the plans. These specifications cover both intersection presence based vehicle detection used for traffic controller input, as well as freeway system or advanced system detection data collection of volume, occupancy and speed.

A. Requirements

The detection system shall provide accurate roadway information as needed to support the traffic management application.

1. The Wireless Battery-Powered Magnetometer Vehicle Detection System shall consist of one or more of the following
 - a. Battery-powered wireless sensors installed in-pavement in each traffic lane w/ reuse enclosure.
 - b. Serial Port Protocol (SPP) Digital Radios mounted on the side of the roadway w/ cable and mount.
 - c. Wireless battery-powered Repeaters (RPs) mounted on the side of the roadway, serving to extend the radio range of an SPP w/ mount.
 - d. Access Point Contact Closure Interface (APCC) cards to provide sensor information processing and support the interface between an SPP and a standard traffic controller using contact closure signals, or mounted in a stand alone cabinet w/ direct IP communications.
 - e. Extension (EX) contact closure cards to provide additional detector outputs to a traffic controller
 - f. Isolation (ISO) Modules to provide surge protection and isolation, as well as providing signal conditioning to enhance the communication distance from the SPP and the APCC.
 - g. Input/Output (I/O) Modules used to provide additional communication options, memory options and a battery backed real time clock.
 - h. Software to control and configure the sensors, APCC, SPP's and RPs.

- i. Communications between a sensor and SPP can be direct, via a single repeater, or via two repeaters operating in tandem. Communications between the sensors and the SPP or RP and between the RP and SPP or another RP shall be via radio.
 - j. Detection data shall be capable of being relayed from each AP to a local traffic controller for real-time vehicle detection using contact closure signals. Data shall also be capable of being relayed directly from each AP to a central software system or central server over standard IP (Internet Protocol) networks.
 - k. Antenna mounted on the side of the roadway, serving to extend the radio range of the AP.
2. WMVD Sensor Type
- a. All sensor components shall be contained within a single housing.
 - The sensor housing shall conform to NEMA Type 6P and IEC IP68 standards.
 - The sensor components shall be fully encapsulated within the housing to prevent moisture from degrading the components.
 - b. Sensor shall be capable of operation within the temperature and humidity limits set forth in NEMA TS2-2003.
 - c. A sensor shall be battery-powered with a minimum lifetime of seven (7) years when the sensor is configured for and operating under normal traffic conditions.
 - d. Two configurations of sensors shall be available from the manufacturer:
 - Type A: shall provide all sensor functions, including data collection functions
 - Type B: shall support presence detection only
 - The drawings and/or plans shall dictate the sensor type required.
3. Serial Port Protocol (SPP) Device
- a. An SPP shall support at least 48 sensors with a 0.125 second latency.
 - b. An SPP shall operate within the temperature and humidity limits set forth in NEMA TS2-2003.
 - c. All SPP components shall be contained within a single housing.
 - d. The SPP housing shall conform to NEMA Type 4X and IEC IP67 standards.
 - e. The SPP shall communicate to the APCC utilizing a standard CAT5e or higher Ethernet cable.
 - f. The SPP shall have a weatherproof Ethernet connector on the bottom.
 - g. The Ethernet connector shall be shipped with a cover firmly attached to provide protection from the elements prior to cable connection.
 - h. The weatherproof connector shall not require any specialized tools for installation.
4. WMVD Repeater (RP)
- a. An RP communicating directly to an AP shall support at least 10 sensors.
 - b. An RP communicating to an AP via an intermediate RP (i.e., tandem operation) shall support at least 6 sensors.
 - c. An RP shall be battery-powered and battery shall last for a minimum of seven years when operating in normal traffic conditions.
 - d. The RP battery shall be field replaceable.
 - e. An RP shall operate within the temperature and humidity range set forth in NEMA TS2-2003.
 - f. All RP components shall be contained within a single housing.
 - g. The RP housing shall conform to NEMA Type 4X and IEC IP67 standards.
5. WMVD Access Point Contact Closure (APCC) Card Type
- a. Each APCC card shall be capable of communicating with at least 2 SPP modules.

- b. Optional Extension (EX) cards shall provide additional contact closures in a signal cabinet (user configurable form 1 to 4 outputs each).
- c. The APCC shall provide all the higher level processing and interface functions of the system.
- d. Each APCC card shall provide detector data as contact closure signals to the traffic controller.
 - Type A: An APCC card shall directly plug in to standard 170/2070 input files.
 - Type B: An APCC card shall be supplied within a standard enclosure to supply power for use in freeway applications.
- e. The APCC and EX cards front panel shall be either software or via front panel switches configurable to provide:
 - Presence or pulse mode
 - Delay timing
 - Extension timing
- f. An APCC and EX card shall operate within the temperature limits set forth in NEMA TS2-2003.
- g. An APCC and EX card shall operate in humidity up to 95% (non-condensing).

6. Isolator module

- a. An Isolator module shall be used between each SPP and APCC to extend communications range and protect the APCC card from transient surges.
- b. The isolator module shall extend the communication range between the APCC and SPP from 33 feet (10 m) to 2000 feet (600 m).
- c. The isolator module shall provide electrical isolation of 1500V.
- d. The isolator module shall provide surge protection of up to 1500V.
- e. The isolator module shall provide AC power cross protection.

7. Input/Output (I/O) Module Type

An I/O module shall expand the capabilities of an APCC by adding a SD Memory Card Slot and battery backed up real time clock. The module shall be of the following types.

- a. Type A: RS232 port for serial communications
- b. Type B: Detection data shall be communicated as IP data over GSM-based cellular data services via a GPRS cellular modem.
- c. Type C: Detection data shall be communicated as IP data over CDMA-based cellular data services via a 1xRTT cellular modem.

The I/O module shall be physically mounted to the APCC and shall be the same width. The combined APCC with I/O module shall be the width of a standard 2 slot wide detector amplifier.

8. Antenna

- a. Antenna shall meet the environmental requirements set forth in NEMA TS2-2003.
- b. Antenna shall operate in an approved frequency band that is compatible with the detection equipment and shall not interfere with any known equipment.
- c. Furnish an antenna that will interface with associated detection equipment. Include all necessary cables and connectors per manufacturer's specification.
- d. Furnish mounting hardware to secure the antenna to the pole as recommended by the manufacturer of the antenna and as approved by the Engineer.
- e. All antenna cable attenuation shall be respective and appropriately sized to the frequency being attenuated at industry standard.

B. Functional Requirements for Wireless Magnetometer Vehicle Detection

1. Sensors

Each sensor shall detect a vehicle by measuring changes in the earth's magnetic field near the sensor as caused by a stopped or passing vehicle (i.e., magnetometer-type detection)

- a. The sensor shall communicate time-stamped ON and OFF vehicle detection events
 - b. Each sensor shall automatically recalibrate in the event of a detector lock
 - c. Each sensor shall communicate by radio to a nearby SPP, AP, antenna, or RP
 - d. Each sensor shall automatically re-transmit a detected event if no acknowledgement is received from the AP
 - e. Each sensor shall respond within 100 seconds when the AP is powered on and transmitting
2. The radio links between each sensor and associated communication link shall conform to the following:
- a. The center frequencies, bandwidths, and transmit power levels of the radio links shall allow operation in an unlicensed frequency band
 - b. Frequency channels shall be employed by the sensors, APs, antenna and RPs to avoid interference with other devices operating in the unlicensed band
 - c. Frequency channels shall be user-configurable when using 2.4GHz
 - d. At least 16 frequency channels shall be supported
3. If detection data is relayed to a central software system or central server, each installation of the Wireless Battery-Powered Magnetometer Vehicle Detection System shall provide the following measurements, as required by the application:
- a. Vehicle volume (count) per lane over a specified time interval
 - b. Lane occupancy (percent) over a specified time interval
 - c. Vehicle speed (mph or kph) when more than one sensor is deployed in a lane
 - d. Per-vehicle speed
 - e. Median speed over a specified time interval
 - f. Mean speed over a specified time interval
 - g. Distribution of speeds over a specified time interval
 - h. Vehicle classification when more than one sensor is deployed in a lane
 - i. Per-vehicle length
 - j. Report distribution of vehicle lengths over a specified time interval
 - k. The time interval for measurements shall be selectable from 30 seconds to 24 hours
4. Each sensor in an installation shall be capable of being individually configured with its own sensitivity level.
- a. A single sensor shall be capable of being configured with a sensitivity level that approximates the detection zone of a standard 6' x 6' inductive loop
 - b. Each sensor shall be capable of being configured with relatively higher or lower sensitivity levels as may be required to detect bicycles, motorcycles, or light rail
 - c. An APCC shall support the relay of sensor detection data through several interfaces as required by the application. The APCC shall be capable of simultaneously communicating detection data via the contact closure interface, Ethernet interface, and cellular data modem interface, as applicable.

C. Accuracy Requirements for the Wireless Magnetometer Vehicle Detection System

Provide a WMVD system that meets the below minimum accuracy requirements for all conditions. Accuracy measurements for the testing shall be done with an appropriate sample size of vehicles, over a specific time period. Submit to the Engineer the Test plan for accuracy testing at the location that is site specific to the plans. The test plan shall take into account the roadway type (freeway, arterial), location (urban, rural), and traffic conditions in order to determine appropriate testing length and sample size. The following conditions shall be met for each sensor installed:

D. Measurement Accuracy

The following error levels shall be achievable and demonstrated during testing for the parameters relevant to each installation.

<u>Parameter</u>	<u>Error Percentage</u>
Presence	±5%
Volume	±8%
Lane Occupancy	±10%
Average Speed	±10%
Length Classification limits	±10%

E. Testing

Develop and submit plans for post-installation testing to the Engineer for consideration and approval. Ensure the plans test all functional requirements outlined in Section 937.2.03B and the accuracy requirements stipulated in Section 937.2.03C. Provide the Engineer with Application Protocol Interface (API) documentation and Software Development Kit (SDK) for the WVDS detection system. GDOT will have 30 days from receipt of the API and SDK to make a determination if it can be integrated. If the device cannot be integrated, the Engineer will give notice that the Contractor must submit a device that can be integrated into the central system software. The testing shall prove that all in-pavement sensors are configured and collecting data as required in this specification and as shown on the plans.

1. Post-installation test procedures: Utilize the following test procedures after the WVDS system has been installed in its entirety as shown on the Plans. Commence no post-installation testing until all WVDS systems in the project have been configured and/or calibrated to gather speed, volume, classification, occupancy, and/or presence and programmed to communicate on the GDOT network as required per installation. Including the accuracy testing requirement, at a minimum, provide the following on the test plan to be submitted and approved by the Engineer:
 - a. Inspect all detection system field components to ensure proper installation and cable termination.
 - b. Verify that field construction has been completed as specified in the plans.
 - c. Inspect the quality and tightness of cable, ground and surge protector connections.
 - d. Check voltage and outputs and ensure device connections are as specified in the Plans and manufacturer recommendations.
 - e. Verify that the installation of cables and connections between all APCC's and field cabinets are as specified in the Plans
 - f. Demonstrate that each Wireless In-Pavement Vehicle Detection System is fully operational, communicating and gathering the required data types at the specified interval.

937.2.04 Short-Range Radio Device Detector System

The Short-Range Radio Device Detection System shall be capable of monitoring and measuring vehicular and pedestrian movement by identifying and comparing unique MAC (Media Access Control) addresses associated with Short-Range Radio enabled electronic devices. The system can be used to collect high quality, high-density travel times by sampling a portion of actual travel activity from the traffic stream of a predetermined route. The MAC address received by a sequence of two or more Short-Range Radio Device receivers shall be matched and used to develop a sample of travel time for that particular segment of the roadway, based on the relative detection times recorded by the adjacent units.

The Short-Range Radio enabled device (sensor) shall be an anonymous Short-Range Radio Device MAC address, which is a hardware identifier for the manufacturer and specific electronic device type. MAC addresses are not associated with any specific user account or any specific vehicle. The MAC address shall not be linked to a specific person through any type of central database, but is assigned by the Short-Range Radio Device electronic chip manufacturer and shall not be tracked through the sales chain. Privacy concerns typically associated with alternative probe systems shall be eliminated.

A. Requirements (Type A, Type B, and Type C)

The Short-Range Radio Device Detection System shall be connected to, and work in conjunction with the support data processing system, located in a designated server at the TMC. All The Short-Range Radio Device Detection units shall adhere to the following requirements:

- Short-Range Radio Device: Class 1 Transceiver with 4 dB to 8 dB Omni Directional Antenna
- Environmental: - 30°C to +65°C, 5 – 90% humidity
- Connectivity: IP/Ethernet 10/100 Base-T (minimum)
- I/O ports: minimum one (1) RJ45 Ethernet port and one (1) RS-232 Configuration Serial Port

1. Short-Range Radio Device Detection System, Type A

Provide a Short-Range Radio Device Detection System that can be installed in a typical signal or ITS cabinet. The unit shall be enclosed in its own housing and sit on a shelf within the cabinet. Utilize a conduit, as shown on the plans, for routing the antenna cable, and attach the antenna at the location shown on the plans. The power for the Short-Range Radio Device Detection System, Type A unit shall come from typical cabinet power (110 VAC) receptacles or terminal block. Supply all wiring for the Short-Range Radio Device Detection System Type A unit. Should the unit require a POE adapter or transformer to VDC, submit the adapter or transformer to the Department for review. The Contractor shall supply all surge protection devices for the external POE adapter or transformer.

2. Short-Range Radio Device Detection System, Type B

Provide a Short-Range Radio Device Detection System that is self enclosed in a NEMA 4X enclosure that can be mounted to a pole, mast arm or cabinet structure. The voltage input shall be between 6 and 30 VDC, or be able to connect to 110 VAC with appropriate transformers and adapters, as determined by the Department. The Short-Range Radio Device Detection System Type B unit shall be wired to a cabinet or approved communication/power source, as shown on the plans. The unit shall not reside within the cabinet. Provide all grounding, wiring, adapters, transformers, and surge protection devices needed to support the Short-Range Radio Device Detection System Type B unit, as installed.

3. Short-Range Radio Device Detection System, Type C

Provide a Short-Range Radio Device Detection System that is self enclosed in a NEMA 4X enclosure that can be mounted to a pole, mast arm or cabinet structure. Provide a Solar Power Array, which includes the solar panel, charging unit and batteries necessary for solar power. The Short-Range Radio Device Detection System Type C unit shall also include a GSM cellular modem with antennas, or approved equivalent. This Short-Range Radio Device Detection System type shall be a completely wireless installation. Provide all grounding, wiring, adapters, transformers, and surge protection devices needed to support the Short-Range Radio Device Detection System Type C unit, as installed.

4. Short-Range Radio Device Detection System Support Data System Software and Database

Provide a Support Data System software package, including all necessary database 3rd party software required in order for the software to run as intended in support and conjunction of the Short-Range Radio Device sensor system. The software shall be installed on a server designated by the Department. It is the Contractor's responsibility to populate and configure the database for each field Short-Range Radio Device Detection System, and to test the accuracy of the data. The data shall be in an XML format compatible with the Department's central software. The software shall also display a real time chart or graph showing calculated travel time and speeds of the sampled vehicles and MAC address counts. The Short-Range Radio Device Detection System support software is required for all new Short-Range Radio Device Detection System installations, but shall not be required for additional Short-Range Radio Device Detection System sensor installations on an existing network.

B. Functional Requirements for the Short-Range Radio Device Detection System

The sensor shall be capable of delivering data from both an Ethernet connection and a GSM wireless modem. The Short-Range Radio Device Detection sensor working in conjunction with the network's support data processing system must deliver real-time speed and travel time information in XML format to the central software system for routes where the sensors are deployed. The system shall be able to add multiple pairs of Short-Range Radio Device Detection sensors to form a network of manageable travel routes. Each route will display the data for the first and last sensor in addition to the travel-time and speed information for that segment. The Short-Range Radio Device Detection sensor shall be able to detect, at a minimum, within a radius of 300 feet when mounted on a pole or mast arm. The data processing shall be able to filter and 'throw out' MAC addresses that do not supply accurate information when compared to other device time stamps of the segment between two Short-Range Radio Detection devices. The data shall be smoothed, and be able to

process median and mean average speeds. The following data shall be able to be compared and filtered, as needed, to deliver the most accurate information:

1. Pedestrians
2. Oversize Vehicles
3. Mass Transit (i.e. nearby trains or buses)

The Short-Range Radio Device Detection System equipment shall contain advanced features designed to allow the unit to operate efficiently in a remote environment. Diagnostic and configuration information shall be able to be viewed remotely, such that the health and operating status of the sensor is known. The system shall be designed to be able to automatically or remotely “reboot” if a condition is detected that requires such action.

C. Testing

Develop and submit plans for post-installation testing to the Engineer for consideration and approval. Ensure the plans test all functional requirements outlined in Section 937.2.03B. Provide the Engineer with the appropriate XML data interface, as necessary, for testing of the travel time accuracy and integration into the central software.

1. Post-installation test procedures: Utilize the following test procedures after the Short-Range Radio Device Detection System has been installed in its entirety as shown on the Plans. Commence no post-installation testing until all Short-Range Radio Device Detection sensors systems in the project have been configured, calibrated and programmed to communicate on the GDOT network to the support data system software. At a minimum, provide the following on the test plan to be submitted and approved by the Engineer:
 - a. Inspect all Short-Range Radio Device Detection System field components to ensure proper installation and cable termination.
 - b. Verify that field construction has been completed as specified in the plans.
 - c. Inspect the quality and tightness of ground and surge protector connections.
 - d. Check power supply voltage and outputs and ensure device connections are as specified in the Plans.
 - e. Verify that the installation of cables and connections between all Short-Range Radio Device units, antennas and field cabinets and/or components are as specified in the Plans
 - f. Demonstrate that each Short-Range Radio Device unit is fully operational and gathering the required data types at the specified and necessary interval.

937.3 Construction/Installation Requirements

This section shall include typical construction requirements for installing and configuring the vehicle detection systems. This specification only gives general requirements of installations. It is the Contractor’s responsibility to be fully certified and trained in the detection technology application and the required installation of such devices by the manufacturer. All cable connections shall be manufacturer-rated and secured from outside elements. The Contractor shall be experienced and/or certified in proper cable/connector crimping and manufacturer sealing methods so as to ensure a water-tight and corrosion resistant installation. Wrap all other exposed cable connections with self sealing tape for weatherproofing and moisture seal.

Refer to Subsection 107.07 of the Specifications regarding proper conduct of The Work.

937.3.01 Personnel

All personnel shall be fully trained and manufacturer certified in the applicable vehicle detection installation application. When installing into a signal or ramp meter cabinet, the technician shall be minimum International Municipal Signal Association (IMSA) Level II certified.

937.3.02 Equipment

Use machinery such as trucks, derricks, bucket vehicles, saws, trenchers, and other equipment necessary for the work and approved by the Engineer prior to installation operations.

937.3.03 Preparation

Utility Permits

A. Application

Apply for, obtain, and pay for utility services, and pole attachment permits required in the Plans.

B. Maintenance

Maintain these utility services until Final Acceptance of each installation. After Final Acceptance, transfer these services and permits to the Department, local government or jurisdiction responsible for maintenance and operation. Ensure that the transfer does not interrupt service.

C. Utility Location

When installing aerial cable of any type, ensure that overhead clearance and separation requirements conform to local utility company standards, OSHA, the NEC and the NESC. Refer to the Standard Details Drawings for further information on utility clearances.

937.3.04 Fabrication

General Provisions 101 through 150.

937.3.05 Construction

A. Video Detection System Installation Requirements

1. General Installation Requirements:

- a. Install all video camera sensors, video detection system processors, output expansion modules, and associated enclosures and equipment at the locations specified in the Plans and per manufacturer recommendations. For traffic signal/ramp meter controller cabinets (Type D, E, and F processors), mount the processor and output expansion modules within the input files, or at a location as designated by the Engineer. Physical changes to the cabinet input files are not permitted. Make all necessary adjustments and modifications to the detection system prior to obtaining recommendation for system acceptance testing. For freeway applications (Type A, B and C processors), install all rack-mounted equipment with one rack unit space between adjacent equipment in the freeway ITS cabinet.
- b. Installation, surge protection and all cabling shall comply with manufacturer's recommendation, at a minimum, or as specified in these plans. All equipment, cables, and hardware must be part of an engineered system that is designed by the manufacturer to fully interoperate with all other system components and be fully protected from all surge potential. Connectors installed outside the cabinets and enclosures shall be manufacturer terminated and be corrosion resistant, weather proof, and watertight. Use a UL listed cable that is ozone and UV resistant and weather resistant. Label cables with permanent cable labels at each end.
- c. Wiring and cables must be continuous (without splices) between the VDS camera sensor and processor, except for surge protection connections between sensor and cabinet, so that both the camera and processor are appropriately protected. Coil a minimum of 6 feet of slack in the bottom of the controller or freeway cabinet. Tape ends of unused and spare conductors to prevent accidental contact to other circuits. Label conductors inside the cabinet for the functions depicted in the approved detailed diagrams of the cabinet and VDS documents.
- d. Furnish an as-built cabinet wiring diagram, identified by location, for each VDS cabinet. Include all wiring, cabling, connections, and camera mounting height. Place all documentation in a weatherproof holder in the cabinet.
- e. For freeway installations (Type A, B and C processors), install VDS power supply or transformer on a standard DIN rail using standard mounting hardware and power conductors wired to terminal blocks in the cabinet.

2. Camera Sensor Installation (all Types)

Adjust the video camera sensor lens as recommended by the manufacturer, and as required to minimize vehicle occlusion. For Type A camera sensors, aim the camera so that no part of the horizon is in the video image so as to

protect it from the effects of the sun. Mount the camera on the specified pole or structure for that location as shown on the plans.

Mounting Bracket Assembly: Mount the video camera sensor on a mounting bracket such that its height and position provide a clear view of the approach or lanes. Mount the video camera sensor securely such that it is stable and steady. The mounting bracket assembly includes a video camera sensor mounting bracket, nipple pipe, cable-mount nipple clamp, and all associated hardware and materials. Mount the video camera sensor on a mounting bracket assembly which meets the following requirements unless otherwise specified in the plans:

- a. Use stainless steel fastening hardware with lock washers on threaded fasteners
- b. Use a video camera sensor enclosure mounting bracket that is non-rusting and is made from die cast aluminum, extruded aluminum, powder-coated galvanized steel or hot dipped galvanized steel. Provide a mounting bracket that permits vertical and horizontal adjustment of the video camera sensor. Provide a mounting bracket that securely fastens to the video camera sensor enclosure and mounts to the nipple pipe by threading onto the pipe or as a slip-fit, using a set-screw fastener in either above method.
- c. Use a 1 1/2" (38 mm) aluminum nipple pipe that is threaded on both ends.
- d. Fasten the nipple pipe to the mast arm using a cable mount nipple clamp with minimum 2 5/16" (58 mm) U bolts. Use aircraft grade galvanized steel cables with stainless steel fastening hardware and that make at least two wraps around the mast arm. Do not use banding straps.

Install all VDS equipment into a cabinet type as shown in the plans with the following equipment:

3. Cabinet Equipment (All Types)

- a. **Wiring, Conductors and Terminal Blocks:** Use stranded copper for all conductors, including those in jacketed cables, except for earth ground conductors, which may be solid copper. Neatly arrange all wiring, firmly lace or bundle it, and mechanically secure the wiring without the use of adhesive fasteners. Route and secure all wiring and cabling to avoid sharp edges and to avoid conflicts with other equipment or cabling. Route camera control wiring, and 120 VAC power wiring separately. Terminate all wiring on a terminal block, strip, bussbar, or device clamp or lug; do not splice any wiring. Use a minimum #12 AWG for all conductors of 120 VAC circuits, or as recommended by the manufacturer of the VDS device.

Label coaxial cables for VDS cameras. Number all terminal blocks, terminal strips, circuit breakers and bussbar breakers and have each item and each terminal position numbered and named according to function. Labels shall be weather and wear resistant.

- b. **Surge Protection:** Protect all copper wiring and cabling entering the cabinet housing by surge protection devices as specified in these specifications and per Section 925.2.02 Section A, part 14. Terminate all wiring between cabinet devices and the transient surge protection devices, except for the video signal coaxial feed, on terminal strips. Use a minimum #16 AWG grounding of each surge protection device, or larger if recommended by the surge protection device manufacturer. Do not "daisy chain" with the grounding wires of other devices including other surge suppressors. Dress and route grounding wires separately from all other cabinet wiring. Install grounding wires with the absolute minimum length possible between the surge protection device and the ground bussbar. Label all surge protection devices with silk-screened lettering on the mounting panel.

Furnish and install a surge suppressor for each video signal coaxial line. Install a BNC connector, three stage surge protection device for the coax cable that employs gas discharge tubes, series current limiting components, and secondary 'fine' protection. The coax surge protection device shall have a surge current rating of 10 kA. For each cabinet housing, include surge protection devices for the VDS camera power lines installed on the terminal bloc.

All surge protection shall be furnished and installed by the Contractor to protect not only the cabinet processor, but the camera sensor itself from ground rise potential (i.e. surge up to the camera sensor).

- c. **Documentation:** Provide the following documentation in a waterproof documentation pouch in each cabinet:
 - One operation manual with programming instructions
 - One maintenance manual with schematics
 - Three legible wiring prints showing all VDS components, model and serial number and connections with the cabinet

4. Cabinet Equipment (Type A, B, and C)

Component Installation: Fasten all components of the cabinet assembly to be mounted on cabinet side panels with hex-head or Phillips-head machine screws. Install the screws into tapped and threaded holes in the panels. These components include but are not limited to terminal blocks, bussbars, panel and socket mounted surge protection devices, accessory and equipment outlets, and DC power supply chassis. Fasten all other cabinet components with hex-head or Phillips-head machine screws insulated with nuts (with locking washer or insert) or into tapped and threaded holes. All fastener heads and nuts (when used) shall be fully accessible within a complete cabinet assembly, and any component shall be removable without requiring removal of other components, panels, or mounting rails. Do not use self-tapping or self-threading fasteners.

5. Cabinet Equipment (Type D, E, and F)

- a. Exercise extreme caution when installing VDS equipment and materials at traffic signal/ramp meter installations. Installation technicians accessing a signal cabinet shall be accompanied by a certified (minimum) International Municipal Signal Association (IMSA) Level II traffic signal technician. Repair any damage to existing traffic/ramp meter control equipment and materials which occurred during VDS installation to the Engineer's satisfaction at the Contractor's sole expense.
- b. In 336S cabinets, locate the VDS power termination panel on the equipment rail in the lower left portion of the rear of the cabinet as shown in the details and plans. Adjust the panel as far toward the cabinet sidewall as possible while still providing access to the circuit breaker. Notify the Engineer immediately if there is any conflict with existing cabinet equipment in this position. Ensure that there is no conflict with door-mounted components when the door is closed.
- c. In 332 and 334 cabinets, locate the VDS coax termination panel in the lower open section of the front of the cabinet equipment rack as shown in the details. Notify the Engineer immediately if there is any conflict with existing cabinet equipment in this position. Ensure that there is no conflict with door-mounted components when the door is closed. Dress, label, and secure all coaxial cabling to and from the coax termination panel such that the panel can be hinged open a minimum of 90 degrees without binding or stressing any coaxial cable.

B. Microwave Detection System Installation Requirements

1. General Installation Requirements

Install all detectors and associated equipment at the locations specified in the Plans. Installation must comply with manufacturer's recommendation. All detector equipment, cables, and hardware must be part of an engineered system that is designed by the manufacturer to fully interoperate with all other system components for the Microwave Detection System. Surge protection devices must be approved by the manufacturer, and must be of quality or better than manufacturer recommendations.

2. Detector

Furnish and Install the microwave radar detector on poles as shown in the plans using Contractor supplied materials and brackets. Install the microwave radar detector to achieve the field of coverage shown in the Plans. Aiming and alignment shall be per the manufacturer's recommendations. The Contractor shall verify height requirements based on manufacturer recommendations and shall notify the Engineer should the mounting height vary from the plans. It is the Contractor's responsibility to make all field adjustments to the locations shown in the Plans, in order to match manufacturer recommendations for operation. All field adjustments shall be approved by the Engineer. The Contractor shall use his laptop to setup the detection zones using detector manufacturer specific software. Use only the latest software that is compatible with the detector, as provided by the manufacturer. Use mounting hardware that meets hardware specifications as described in the Video Detection System Installation Requirements, mounting hardware assembly.

3. Cabinet Equipment

- a. Wiring, Conductors, and Terminal Blocks: Furnish and Install a manufacturer terminated cable of length necessary for the detector installation. Use only cables provided by the manufacturer of the detection system. The detector end-connector shall be manufacturer assembled and tested prior to installation. It shall be completely watertight and weather resistant. All cabling shall be UV rated for outdoor and underground use. Use only stranded copper for all conductors, including those in jacketed cables, except for earth ground conductors, which may be solid copper. Neatly arrange all wiring, firmly lace or bundle it, and mechanically secure the wiring without the use of adhesive fasteners. Route and secure all wiring and cabling to avoid

sharp edges and to avoid conflicts with other equipment or cabling. Route microwave radar detector control wiring and 120VAC power wiring separately so as no transient voltage bleeds over to the detector cable. Terminate all wiring on a terminal block, strip, bussbar, or device clamp or lug; do not splice any wiring from the detector unit to the terminal blocks.

Number and label all terminal blocks, terminal strips, circuit breakers and bussbar breakers and have each item and each terminal position numbered and named according to function. Label terminal blocks, terminal strips, circuit breakers and bussbars with weather and wear resistant labels.

- b. Surge Protection Devices (SPD): Protect all copper wiring and cabling entering the cabinet housing by surge protection devices as specified in this specification and the minimum requirements of Section 925.2.02 Section A, part 14. Terminate all wiring between cabinet devices and the transient surge protection devices and between the microwave radar detection unit and the surge protectors on terminal strips. Use a minimum #16 AWG grounding for each surge protection device, or larger if recommended by the surge protection device manufacturer. Use insulated green wire and connect the ground wire directly to the ground bussbar. Do not “daisy chain” with the grounding wires of other devices including other surge protection devices. Dress and route grounding wires separately from all other cabinet wiring. Install grounding wires with the absolute minimum length possible between the suppressor and the ground bussbar. Label all surge suppressors with silk-screened lettering on the mounting panel.

Furnish and install all necessary transient surge protection devices for the microwave radar detection units such that the detector and cabinet equipment are protected.

- c. Component Installation: Fasten all components of the cabinet assembly to be mounted on cabinet side panels with hex-head or Phillips-head machine screws. Install the screws into tapped and threaded holes in the panels. The components include but are not limited to terminal blocks, bussbars, panel and socket mounted surge protectors, terminal servers, Ethernet switches, circuit breakers, and accessory and equipment outlets. Fasten all other cabinet components with hex-head or Phillips-head machine screws installed with nuts (with locking washer or insert) or into tapped and threaded holes. Fasten stud-mounted components to a mounting bracket providing complete access to the studs and mounting nuts. All fastener heads and nuts (when used) shall be fully accessible within a complete cabinet assembly, and any component shall be removable without requiring removal of other components, panels, or mounting rails. Do not use self-tapping or self-threading fasteners.
- d. As-Built Drawings: Furnish an as-built cabinet wiring diagram, identified by location, for each cabinet. Include label names and numbering, surge protection devices (SPD's), wiring, cabling, and connections. Place all documentation in a weatherproof holder in the cabinet.

4. Cables, Conduit and Power Service

Furnish and install electrical cables used for control, communications signaling and power supply as required by the manufacturer. Do not splice any cable, shield or conductor used for control, communications signaling, or power supply. Identify all conductors of all cables by color and number. Identify the conductor function in as-built documentation included in the cabinet documentation. After termination and dressing the cables in the cabinet, neatly coil and store a minimum of 6 ft of cable slack in the bottom of the cabinet. Cut unused conductors to a length that can reach any appropriate terminal. Bend back unused conductors over their outer jackets and individually tape them.

Install cabling inside new hollow metal or concrete support poles unless otherwise specified. Where devices are installed on existing wood poles, install cabling on the wood poles in rigid metal conduit risers of minimum 2 inch (5.08 cm) diameter. Use weatherheads on all nipple and conduit openings. Neatly install and route cabling to minimize movement in the wind and chafing against the pole, device or bracket. Form a drip loop at the weather head and route cabling to minimize water entry into the cable connector. Use a 24" diameter drip loop where cables enter a weatherhead.

5. As-Built Drawings

Furnish as-built drawings that include the cabinet wiring diagrams as outlined in 2d above. As-built drawings shall include but not be limited to microwave radar detection locations, microwave radar detection mounting heights, and component lists with brand, model and serial numbers. Place one copy of the as-built drawings in the cabinet documentation pouch and submit another copy to the Engineer.

C. Wireless Magnetometer Vehicle Detection

1. General Installation Requirements

Each installation of the Wireless Battery-Powered Magnetometer Vehicle Detection System shall consist of one or more sensors installed in the center of each traffic lane, avoiding sources of magnetic noise such as underground power cables, overhead high tension power cables, light rail or subway tracks, and power generation stations and sub-stations.

- a. The sensors shall be located as specified by the plans
- b. For count applications, sensors shall be placed in areas with minimum stop-and-go traffic flow
- c. If vehicle speeds are to be determined by the system, then at least two sensors are required in each lane, separated according to the anticipated average vehicle speed.
 - If the anticipated average vehicle speed is less than 25 mph / 40 kph, the spacing between sensors shall be approximately 10 feet / 3 meters (and measured precisely at the time of installation in order to properly configure the system)
 - If the anticipated average vehicle speed is greater than 25 mph / 40 kph but less than 45 mph / 75 kph, the spacing between sensors shall be approximately 10 to 12 feet / 3.1 to 3.7 meters (and measured precisely at the time of installation in order to properly configure the system)
 - If the anticipated average vehicle speed is greater than 45 mph / 75 kph, the spacing between sensors shall be approximately 20 to 24 feet / 6.1 to 7.3 meters (and measured precisely at the time of installation in order to properly configure the system)

Prior to installation, the contractor shall provide personnel that have been certified by the manufacturer to test and pre-configure the components, including assigning channels and sensors to SPP, RP's, etc. The Contractor shall record all detection component ID numbers on a project plans drawing or intersection detail prior to installation, and supply all drawings showing the recordings as part of the as-builts at the end of the project. The Contractor shall install each sensor in the roadway per Manufacturer's recommendations. The contractor will install Type B sensors for stop bar detection only, where presence is only required, and Type A sensors will be deployed for all other detection applications.

2. Sensor Installation:

For a sensor installed just below the roadway surface:

- a. The roadway shall be core drilled to provide a 4" diameter hole, a minimum 2.25" / 5.7 cm deep
- b. The sensor shall be placed inside a small, clear plastic shell formed to provide a tight fit around the sensor.
- c. A small layer of epoxy approximately 1.25" / 3.2 cm shall be applied to the bottom of the cored hole.
- d. The epoxy must adhere to the following requirements:
 - The epoxy shall be a two part poly-urea based joint sealant.
 - It shall have self-leveling characteristics.
 - The surface the epoxy will be bonding to shall be free of debris, moisture and anything else which might interfere with the bonding process.
- e. The epoxy shall be approved by the manufacturer of the detection system
- f. The sensor shall then be placed on top of this layer of epoxy in the correct orientation as clearly marked on the sensor
- g. The sensor shall be fully encapsulated with the epoxy to the lip of the cored hole

3. Sensor to Repeater, or Sensor to SPP Installation:

The maximum distance between a sensor installed in the roadway and an SPP or an RP with a clear line-of-sight between devices shall be:

- a. At least 175 feet / 53 meters for an SPP or RP installed 30 feet / 9 meters above the roadway
- b. At least 150 feet / 46 meters for an SPP or RP installed 20 feet / 6 meters above the roadway

- c. At least 125 feet / 38 meters for an SPP or RP installed 16 feet / 5 meters above the roadway
 - d. The maximum distance between an SPP and an RP or between an RP and another RP shall be at least 750 feet / 228.6 meters when both units are installed 18 feet / 5.5 meters above the roadway and with a clear line-of-sight between devices
4. Repeater to SPP Installation:
- Maximum wireless distances shall be based on the following:
- a. SPP or Repeater front of the housing shall be aimed directly at the device (SPP, RP or Sensor) it is communicating with
 - b. Deviations from the centerline of the front of the SPP or RP shall reduce the effective distance of communication

D. Short-Range Radio Device Detection System Installation Requirements

1. General Installation Requirements
2. Install the Short-Range Radio Device Detection antenna and/or NEMA 4X enclosure on poles as shown in the plans using Contractor supplied materials and brackets. Install the Short-Range Radio Device Detector to achieve the field of coverage shown in the Plans. Make field adjustments to the locations shown in the Plans only with the Engineer's approval.
3. The minimum recommended mounting height for the Short-Range Radio Device sensor antenna shall be 10 feet above grade, unless otherwise approved by the Engineer. When using a solar power supply the panel shall be mounted in accordance with environmental and location geographic conditions, and as shown and noted in the plans. It shall be the Contractor's responsibility to tune the sensor for best coverage of the roadway vehicles being detected.
4. All mounting hardware shall be stainless steel or aluminum, and shall not be susceptible to weather and rusting. Use mounting hardware specifications as outlined in the Video Detection System Installation Requirements. Route all cabling within new conduit, unless otherwise approved by the Engineer. Protect the Short-Range Radio Device processor from the antenna with a surge protection device of specification recommended by the manufacturer.
5. It is the Contractor's responsibility to populate and configure the database and support data system software package and to test the accuracy of the data. Each Short-Range Radio Device Detector shall be configured in the software and show that it is taking a representative sample of vehicles from the traffic stream.

937.3.06 Quality Acceptance/Testing

The acceptance testing of the vehicle detection systems shall consist of two phases: 1) post installation detection system site testing, as outlined in the specific detection technology sections; and 2) burn-in period. Perform acceptance testing for all equipment, hardware and work as provided under this Contract. Perform all testing in the presence of the Engineer. Submit all testing plans and documents to the Engineer during the submittal phase of the vehicle detection equipment.

A. Burn-in Period

1. General Requirements
2. Provide a 30-day burn-in period for all work and equipment included in the Contract and associated with the vehicle detection equipment. The burn-in period shall consist of the field operation of the specific vehicle detection system in a manner that is in full accordance with the requirements of the Plans and Specifications.
3. Conduct only one (1) burn-in period on the entire Contract for all vehicle detection devices. Commence with the burn-in period only after meeting all of the following requirements:
 - All work required in all Contract documents for the vehicle detection system project-wide has been completed and inspected by the Engineer.
 - Successfully complete the Post-Installation Vehicle Detection System Site Testing.
4. Commence with the burn-in period upon written authorization by the Department to commence. Terminate the burn-in period 30 consecutive days thereafter unless an equipment malfunction occurs. Stop the burn-in period for the length of time any equipment is defective. After repairing the equipment so that it functions properly, resume the burn-in period at the point it was stopped.
5. Successful completion and acceptance of the burn-in period will be granted on the 31st day unless any equipment has malfunctioned. If any equipment has failed during the burn-in period, final acceptance will be withheld until all the equipment is functioning properly.
6. When one specific piece of equipment has malfunctioned more than three times during the 30 day burn-in period, replace that unit with a new unit at no cost to the Department. Multiple failures of detection devices in different locations shall be determined as a failure of the 30 day burn-in period. The Contractor shall investigate the detection system failure and shall give a full report to the Engineer. The Contractor shall replace the failed devices and shall restart the burn-in period at Day 1, once those devices have been replaced and retested.

7. Contractor Responsibilities

During the burn-in period, maintain all work under this Contract in accordance with the Specifications. Restore any work or equipment to proper operating condition within 12 hours after notification.

8. Department Responsibilities

Department responsibilities during the burn-in period will be as follows:

- Expeditious notification of Contractor upon failure or malfunction of equipment
- In the event that the Contractor does not provide the services enumerated above under his Contract responsibilities, the Department or its authorized agents may in the interest of public safety take emergency action to provide for adequate traffic control. Pay any costs incurred as a result of these emergency actions. Such action by the Department will not void any guaranties or warranties or other obligations set forth in the Contract.

9. Burn-In Period Acceptance

The Department will make burn-in period acceptance after satisfactory completion of the required burn-in period and on the basis of a comprehensive field inspection of the complete vehicle detection system in accordance with the Specifications. Upon burn-in period acceptance but prior to Final Acceptance of the entire Contract, maintain the complete vehicle detection system in accordance with the specifications.

937.3.07 Contractor Warranty and Maintenance

Equipment provided under this specification shall be warranted by the manufacturer to be free from defects in materials and workmanship for a minimum of three (3) years from Maintenance Acceptance.

The manufacturer's and supplier's warranties shall be transferable to the agency or user that is responsible for maintenance and shall be continuous throughout their duration.

During the warranty period, the manufacturer shall repair or replace any faulty equipment without cost to the purchaser, State of Georgia, or maintaining agency for all incidentals to the repair or replacement, including but not limited to parts, labor, or shipping.

The manufacturer shall be responsible for providing firmware or software updates associated with the CCTV system at no cost to the State of Georgia or maintaining agency during the warranty period. Further, the manufacturer is also responsible for ensuring that any updates will not degrade the original functionality of the product warranted.

The manufacturer and/or supplier shall provide consultation to the Department or user that is responsible for maintenance as needed at no cost during the warranty period for operating questions or problems that arise.

937.3.08 Training

Provide a minimum of at least eight (8) hours of configuration and maintenance training. The persons to be trained will be determined by the Engineer. Configuration training should last a minimum of three (3) hours and must include instructions for programming, hands on training in programming detection zones, adjusting, and calibrating the detection system. One hands on unit shall be provided per attendee during training. Operation and Maintenance training should last a minimum of five (5) hours and must include instructions on troubleshooting, maintenance, and operation for all detection system components. Each class will have a maximum of eight (8) people. The contractor must provide a training notebook to each trainee and an electronic copy of the training notebook to the Engineer.

The contractor must provide a location for holding the courses and pay all costs associated with travel and accommodation of the trainees if training is conducted away from the project area.

Notify the Engineer 20 days before training and agree on a time and place to conduct the training. If agreement cannot be reached, the Engineer will determine the time.

937.4 Measurement

937.4.01 Video Detection System

A. Video Camera Sensor Assembly (All Types)

Video camera sensor assemblies are measured for payment per each actually installed, complete, functional, and accepted. Unless otherwise specified in the Plans, furnish and install the following minimum items for a video camera sensor assembly.

1. Camera, environmental enclosure, and mounting assembly with all associated hardware.
2. Cabinet equipment, including but not limited to wiring, conductors, terminal blocks, surge protection devices, and mounting panels
3. All weather heads, vertical conduit risers, and conduit hardware on the VDS support pole for power service, grounding, communications, and control. If VDS and CCTV are mounted on the same pole, install common weather heads, conduit risers, and conduit hardware under Section 936 of the Specifications.
4. All hardware and materials necessary to provide electrical power service to the VDS field location as shown in the Plans, including but not limited to vertical sections of conduit, conduit hardware, wire, circuit breakers, disconnect closures, and grounding. The Department will pay for horizontal sections of conduit separately.
5. All cables, connectors, hardware, interfaces, supplies, and any other items necessary for the proper operation and function of any VDS system component to carry video signals to the video detection system processor. All cables shall have manufacturer installed and tested connector ends at the detection side of the cable.

B. Video Detection System Processor (All Types)

Video detection system processors are measured for payment per each actually installed, configured, complete, functional, and accepted. Unless otherwise specified in the Plans, furnish and install a video detection system processor to include, at a minimum, the following:

1. Video detection system processor module
2. Appropriate power supplies, power and communication wiring.
3. Necessary housing and rack assemblies for processors that do not plug directly into signal cabinet input files
4. System software provided within the video detection system processor and configuration software

C. Output Expansion Module

Output expansion modules are measured for payment per each actually installed, complete, functional, and accepted. Unless otherwise specified in the Plans, furnish and install an Output Expansion Module to include, at a minimum, the following:

1. Output expansion module
2. Any cabling and hardware required to connect to the processor module or additional expansion modules to the cabinet and controller input pins

D. Testing

Testing is measured as a lump sum for full delivery of testing and acceptance requirements.

E. Training

Training is measured as a lump sum for all supplies, equipment, materials, handouts, travel, and subsistence necessary to conduct the training.

937.4.02 Microwave Radar Detection

A. Microwave Radar Detector Assembly

Microwave radar detection assemblies are measured for payment per each actually installed, complete, functional, and accepted. Unless otherwise specified in the Plans, furnish and install the following minimum items for a microwave detection assembly:

1. Microwave radar detector (including housing)
2. Field cabling surge protection devices, and cabinet equipment. Field cable shall have manufacturer installed end connector at the detection end
3. Power supply modules
4. Serial communication modules
5. Local communication modules
6. Mounting bracket(s)
7. All weatherheads, vertical conduit risers, and conduit hardware on the support pole for power and detector signal as shown in the plans
8. Configuration and Software

B. Testing

Testing is measured as a lump sum for full delivery of testing and acceptance requirements.

C. Training

Training is measured as a lump sum for all supplies, equipment, materials, handouts, travel, and subsistence necessary to conduct the training.

937.4.03 Wireless In-Pavement Vehicle Detection

A. Sensor (All Types)

Sensors are measured for payment per each actually installed, complete, functional, and accepted. Unless otherwise specified in the Plans, furnish and install the following minimum items for a sensor detection assembly:

1. Sensor
2. Epoxy
3. Core Drilling and Placement
4. Sensor plastic enclosure
5. Configuration and Software

B. Access Point Contact Closure (All Types)

Access Point Contact Closure assemblies are measured for payment per each actually installed, complete, functional, and accepted. Unless otherwise specified in the Plans, the APCC shall include all configuration, software, enclosures, surge protection devices and power supplies, as necessary for a full installation. Provide all modules and cabling with the APCC for connection directly into an Ethernet switch.

C. Wireless Repeater

Repeaters are measured for payment per each actually installed, complete, functional, and accepted. Unless otherwise specified in the Plans, furnish and install the following minimum items for a wireless repeater assembly:

1. Repeater including housing
2. 7-year battery
3. Mounting hardware
4. Configuration and Software

D. Serial Port Protocol Unit (SPP)

SPP's are measured for payment per each actually installed, complete, functional, and accepted. Unless otherwise specified in the Plans, furnish and install the following minimum items for a SPP assembly:

1. Radio unit including housing
2. Cabling, surge protection devices and connectors from unit to cabinet
3. Mounting hardware
4. Configuration and Software

E. Expansion Contact Closure Card

Expansion Contact Closure Cards (EX) are measured for payment per each actually installed, complete, functional, and accepted. The EX card shall include all configuration to provide a full contact closure detection system.

F. Isolator Module

Isolator Modules are measured for payment per each actually installed, complete, functional, and accepted. Unless otherwise specified in the Plans, furnish and install the isolation module at all locations the Wireless In-Pavement Detection System is called out in the plans. Ensure that the isolation module is installed per the manufacturer recommendation and is providing protection and amplification of the signal. This shall include all configuration of the unit.

G. Input/Output Module

Input/Output Modules are measured for payment per each actually installed, complete, functional, and accepted. Ensure that the Input/Output module is installed per the manufacturer recommendation and is providing the correct communications options necessary for the installation. This shall include all configuration of the unit.

H. Testing

Testing is measured as a lump sum for full delivery of testing and acceptance requirements.

I. Training

Training is measured as a lump sum for all supplies, equipment, materials, handouts, travel, and subsistence necessary to conduct the training.

937.4.04 Short-Range Radio Device Detection System (All Types)

A. Short-Range Radio Device Detection System (All Types)

Short-Range Radio Device Detectors are measured for payment per each actually installed, complete, functional, and accepted. Each type of system shall be complete, installed and in place and include all units necessary for full operation, as determined by Type. Unless otherwise specified in the Plans, furnish and install the following minimum items for a Short-Range Radio Device Detection assembly:

1. Short-Range Radio Device Detection assembly, including housing and necessary power supplies
2. Power and communications cabling
3. Antenna and mounting hardware
4. Surge Protection Devices
5. Cellular Modem (if applicable)
6. Solar Panel Array (if applicable)
7. Solar Battery charger (if applicable)
8. Batteries (if applicable)
9. NEMA 4X Enclosure (if applicable)
10. Configuration

B. Short-Range Radio Device Detection System Support Data System Software and Database Package

Short-Range Radio Device Detection System software and database packages are measured for payment per each package actually installed, complete, functional, and accepted. Each type of system shall be complete, installed and in place. Unless otherwise specified in the Plans, furnish and install the following minimum items for Short-Range Radio Device Detection System software:

1. Installation of the Software on a Department determined server
2. Installation of the Database software on a Department determined server
3. Configuration of the Short-Range Radio Device Detection System units and initial testing on the software
4. Testing of the XML data and interface to the central system

937.5 Payment

A. General

All Vehicle Detection assemblies, complete in place and accepted by the Department after a successful 30 day burn-in period, are paid for at the Contract Unit Price. Payment is full compensation for furnishing and installing the vehicle detection technology as shown on the plans.

B. Testing

The Department will pay for testing performed as prescribed by this Item, measured as provided under Measurement at the Lump Sum Contract bid price.

C. Training

Training is paid for as a lump sum for all supplies, equipment, materials, handouts, travel, and subsistence necessary to conduct the training, measured as provided under Measurement at the Lump Sum Contract bid price

Payment is full compensation for furnishing and installing the items complete in plans according to this Specification.

Payment will be made under:

Item No. 937	Video Camera Sensor Assembly, Type_	Per Each
Item No. 937	VDS System Processor, Type _	Per Each
Item No. 937	Output Expansion Module, Type _	Per Each
Item No. 937	Testing - Video Detection System	Lump Sum
Item No. 937	Training - Video Detection System	Lump Sum
Item No. 937	Microwave Radar Detection Assembly	Per Each
Item No. 937	Testing - Microwave Detection System	Lump Sum
Item No. 937	Training - Microwave Detection System	Lump Sum
Item No. 937	Wireless Magnetometer Sensor Type _	Per Each
Item No. 937	Access Point Contact Closure Type _	Per Each
Item No. 937	Wireless Repeater	Per Each
Item No. 937	Serial Port Protocol Unit	Per Each
Item No. 937	Expansion Contact Closure Card	Per Each

Item No. 937	Isolator Module	Per Each
Item No. 937	Input/Output Module	Per Each
Item No. 937	Testing – WMVD System	Lump Sum
Item No. 937	Training – WMVD System	Lump Sum
Item No. 937	Short-Range Radio Device Detection System Type _	Per Each
Item No. 937	Short-Range Radio Device Support Data Processing Software Package	Per Each
Item No. 937	Testing – Short-Range Radio Device Detection System	Lump Sum
Item No. 937	Training – Short-Range Radio Device Detection System	Lump Sum