VOLUME II TECHNICAL SPECIFICATIONS FOR RUNWAY I 6R-34L RECONSTRUCTION PROJECT RENO-TAHOE INTERNATIONAL AIRPORT

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RENO-TAHOE INTERNATIONAL AIRPORT

RUNWAY 16R-34L RECONSTRUCTION PROJECT

PROJECT MANUAL

VOLUME II TECHNICAL SPECIFICATIONS

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The following specifications were prepared by:

Wood Rodgers, Inc.

1361 Corporate Blvd Reno, NV 89502



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The following specifications were prepared by:

Lean Engineering

18850 Von Karman Drive, Suite 200 Irvine, California 92612



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ITEM C-100 CONTRACTOR QUALITY CONTROL PROGRAM (CQCP)

100-1 GENERAL. Quality is more than test results. Quality is the combination of proper materials, testing, workmanship, equipment, inspection, and documentation of the project. Establishing and maintaining a culture of quality is key to achieving a quality project. The Contractor shall establish, provide, and maintain an effective Contractor Quality Control Program (CQCP) that details the methods and procedures that will be taken to assure that all materials and completed construction required by this contract conform to contract plans, technical specifications and other requirements, whether manufactured by the Contractor, or procured from subcontractors or vendors. Although guidelines are established and certain minimum requirements are specified here and elsewhere in the contract technical specifications, the Contractor shall assume full responsibility for accomplishing the stated purpose.

The Contractor shall establish a CQCP that will:

- **a.** Provide qualified personnel to develop and implement the CQCP.
- **b.** Provide for the production of acceptable quality materials.
- **c.** Provide sufficient information to assure that the specification requirements can be met.
- **d.** Document the CQCP process.

The Contractor shall not begin any construction or production of materials to be incorporated into the completed work until the CQCP has been reviewed and approved by the Engineer. No partial payment will be made for materials subject to specific quality control (QC) requirements until the CQCP has been reviewed and approved.

The QC requirements contained in this section and elsewhere in the contract technical specifications are in addition to and separate from the quality assurance (QA) testing requirements. QA testing requirements are the responsibility of the Construction Manager or Contractor as specified in the specifications.

A Quality Control (QC)/Quality Assurance (QA) workshop with the Engineer, Construction Manager, Contractor, subcontractors, testing laboratories, and Owner's representative must be held prior to start of construction. The QC/QA workshop will be facilitated by the Contractor. The Contractor shall coordinate with the Airport and the Construction Manager on time and location of the QC/QA workshop. Items to be addressed, at a minimum, will include:

a. Review of the CQCP including submittals, QC Testing, Action & Suspension Limits for Production, Corrective Action Plans, Distribution of QC reports, and Control Charts.

b. Discussion of the QA program.

c. Discussion of the QC and QA Organization and authority including coordination and information exchange between QC and QA.

d. Establish regular meetings to discuss control of materials, methods and testing.

e. Establishment of the overall QC culture.

100-2 DESCRIPTION OF PROGRAM.

- <u>A.</u> <u>General description.</u> The Contractor shall establish a CQCP to perform QC inspection and testing of all items of work required by the technical specifications, including those performed by subcontractors. The CQCP shall ensure conformance to applicable specifications and plans with respect to materials, off-site fabrication, workmanship, construction, finish, and functional performance. The CQCP shall be effective for control of all construction work performed under this Contract and shall specifically include surveillance and tests required by the technical specifications, in addition to other requirements of this section and any other activities deemed necessary by the Contractor to establish an effective level of QC.
- <u>B. Contractor Quality Control Program (CQCP).</u> The Contractor shall describe the CQCP in a written document that shall be reviewed and approved by the Engineer prior to the start of any production, construction, or off-site fabrication. The written CQCP shall be submitted to the Engineer for review and approval at least 10 calendar days before the CQCP Workshop. The Contractor's CQCP and QC testing laboratory must be approved in writing by the Engineer prior to the Notice to Proceed (NTP).

The CQCP shall be organized to address, as a minimum, the following:

- 1. QC organization and resumes of key staff
- 2. Project progress schedule
- 3. Submittals schedule
- 4. Inspection requirements
- 5. QC testing plan
- 6. Documentation of QC activities and distribution of QC reports
- 7. Requirements for corrective action when QC and/or QA acceptance criteria are not met
- 8. Material quality and construction means and methods. Address all elements applicable to the project that affect the quality of the pavement structure including subgrade, subbase, base, and surface course. Some elements that must be addressed include, but is not limited to mix design, aggregate grading, stockpile management, mixing and transporting, placing and finishing, quality control testing and inspection, smoothness, laydown plan, equipment, and temperature management plan.

The Contractor must add any additional elements to the CQCP that is necessary to adequately control all production and/or construction processes required by this contract.

<u>100-3</u> CQCP ORGANIZATION. The CQCP shall be implemented by the establishment of a QC organization. An organizational chart shall be developed to show all QC personnel, their authority, and how these personnel integrate with other management/production and construction functions and personnel.

The organizational chart shall identify all QC staff by name and function, and shall indicate the total staff required to implement all elements of the CQCP, including inspection and testing for each item of work. If necessary, different technicians can be used for specific inspection and testing functions for different items of work. If an outside organization or independent testing laboratory is used for implementation of all or part of the CQCP, the personnel assigned shall be subject to the qualification requirements of paragraphs 100-03a and 100-03b. The organizational chart shall indicate which personnel are Contractor employees and which are provided by an outside organization.

The QC organization shall, as a minimum, consist of the following personnel:

a. Program Administrator. The Contractor Quality Control Program Administrator (CQCPA) must be a full-time on-site employee of the Contractor, or a consultant engaged by the Contractor. The CQCPA must have a minimum of five (5) years of experience in QC pavement construction with prior QC experience on a project of comparable size and scope as the contract.

Included in the five (5) years of paving/QC experience, the CQCPA must meet at least one of the following requirements:

- (1) Professional Engineer with one (1) year of airport paving experience.
- (2) Engineer-in-training with two (2) years of airport paving experience.
- (3) National Institute for Certification in Engineering Technologies (NICET) Civil Engineering Technology Level IV with three (3) years of airport paving experience.
- (4) An individual with four (4) years of airport paving experience, with a Bachelor of Science Degree in Civil Engineering, Civil Engineering Technology or Construction.

The CQCPA must have full authority to institute any and all actions necessary for the successful implementation of the CQCP to ensure compliance with the contract plans and technical specifications. The CQCPA authority must include the ability to immediately stop production until materials and/or processes are in compliance with contract specifications. The CQCPA must report directly to a principal officer of the construction firm. The CQCPA may not supervise the Quality Control Program on more than one project without the prior approval of the Construction Manager.

<u>B. QC technicians.</u> A sufficient number of QC technicians necessary to adequately implement the CQCP must be provided. These personnel must be either Engineers, engineering technicians, or experienced craftsman with qualifications in the appropriate field equivalent to NICET Level II in Civil Engineering Technology or higher, and shall have a minimum of two (2) years of experience in their area of expertise.

The QC technicians must report directly to the CQCPA and shall perform the following functions:

- (1) Inspection of all materials, construction, plant, and equipment for conformance to the technical specifications, and as required by paragraph 100-6.
- (2) Performance of all QC tests as required by the technical specifications and paragraph100-8.
- (3) Performance of tests for the Construction Manager when required by the technical specifications.

Certification at an equivalent level of qualification and experience by a state or nationally recognized organization will be acceptable in lieu of NICET certification.

<u>C. Staffing levels.</u> The Contractor shall provide sufficient qualified QC personnel to monitor each work activity at all times. Where material is being produced in a plant for incorporation into the work, separate plant and field technicians shall be provided at each plant and field placement location. The scheduling and coordinating of all inspection and testing must match the type and pace of work activity. The CQCP shall state where different technicians will be required for different work elements.

100-4 PROJECT PROGRESS SCHEDULE. Critical QC activities must be shown on the project schedule as required by Section 80, paragraph 80-03, *Execution and Progress*.

100-5 SUBMITTALS SCHEDULE. The Contractor shall submit a detailed listing of all submittals (for example, mix designs, material certifications) and shop drawings required by the technical specifications. The listing can be developed in a spreadsheet format and shall include as a minimum:

- A. Specification item number
- B. Item description
- C. Description of submittal
- D. Specification paragraph requiring submittal
- E. Scheduled date of submittal

<u>100-6</u> INSPECTION REQUIREMENTS. QC inspection functions shall be organized to provide inspections for all definable features of work, as detailed below. All inspections shall be documented by the Contractor as specified by paragraph 100-9.

Inspections shall be performed as needed to ensure continuing compliance with contract requirements until completion of the particular feature of work. Inspections shall include the following minimum requirements:

a. During plant operation for material production, QC test results and periodic inspections shall be used to ensure the quality of aggregates and other mix components, and to adjust and control mix proportioning to meet the approved mix design and other requirements of the technical specifications. All equipment used in proportioning and mixing shall be inspected to ensure its proper operating condition. The CQCP shall detail how these and other QC functions will be accomplished and used.

b. During field operations, QC test results and periodic inspections shall be used to ensure the quality of all materials and workmanship. All equipment used in placing, finishing, and compacting shall be inspected to ensure its proper operating condition and to ensure that all such operations are in conformance to the technical specifications and are within the plan dimensions, lines, grades, and tolerances specified. The CQCP shall document how these and other QC functions will be accomplished and used.

100-7 CONTRACTOR QC TESTING FACILITY.

a. For projects that include Item P-401, Item P-403, and Item P-404, the Contractor shall ensure facilities, including all necessary equipment, materials, and current reference standards, are provided that meet requirements in the following paragraphs of ASTM D3666, *Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials*:

8.1.3 Equipment Calibration and Checks;

8.1.9 Equipment Calibration, Standardization, and Check Records;

8.1.12 Test Methods and Procedures

b. For projects that include P-501, the Contractor shall ensure facilities, including all necessary equipment, materials, and current reference standards, are provided that meet requirements in the following paragraphs of ASTM C1077, Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation:

7 Test Methods and Procedures

8 Facilities, Equipment, and Supplemental Procedures

100-8 QC TESTING PLAN. As a part of the overall CQCP, the Contractor shall implement a QC testing plan, as required by the technical specifications. The testing plan shall include the minimum tests and test frequencies required by each technical specification Item, as well as any additional QC tests that the Contractor deems necessary to adequately control production and/or construction processes.

The QC testing plan can be developed in a spreadsheet fashion and shall, as a minimum, include the following:

a. Specification item number (e.g., P-401)

b. Item description (e.g., Hot Mix Asphalt Pavements)

c. Test type (e.g., gradation, grade, asphalt content)

d. Test standard (e.g., ASTM or American Association of State Highway and Transportation Officials (AASHTO) test number, as applicable)

e. Test frequency (e.g., as required by technical specifications or minimum frequency when requirements are not stated)

f. Responsibility (e.g., plant technician)

g. Control requirements (e.g., target, permissible deviations)

The QC testing plan shall contain a statistically-based procedure of random sampling for acquiring test samples in accordance with ASTM D3665. The Construction Manager shall be provided the opportunity to witness QC sampling and testing.

All QC test results shall be documented by the Contractor as required by paragraph 100-9.

100-9 DOCUMENTATION. The Contractor shall maintain current QC records of all inspections and tests performed. These records shall include factual evidence that the required QC inspections or tests have been performed, including type and number of inspections or tests involved; results of inspections or tests; nature of defects, deviations, causes for rejection, etc.; proposed remedial action; and corrective actions taken.

These records must cover both conforming and defective or deficient features, and must include a statement that all supplies and materials incorporated in the work are in full compliance with the terms of the contract. Legible copies of these records shall be furnished to the Construction Manager daily. The records shall cover all work placed subsequent to the previously furnished records and shall be verified and signed by the CQCPA.

Contractor QC records required for the contract shall include, but are not necessarily limited to, the following records:

a. Daily inspection reports. Each Contractor QC technician shall maintain a daily log of all inspections performed for both Contractor and subcontractor operations. These technician's daily reports shall provide factual evidence that continuous QC inspections have been performed and shall, as a minimum, include the following:

- (1) Technical specification item number and description
- (2) Compliance with approved submittals
- (3) Proper storage of materials and equipment
- (4) Proper operation of all equipment
- (5) Adherence to plans and technical specifications
- (6) Summary of any necessary corrective actions
- (7) Safety inspection.
- (8) Photographs and/or video

The daily inspection reports shall identify all QC inspections and QC tests conducted, results of inspections, location and nature of defects found, causes for rejection, and remedial or corrective actions taken or proposed.

The daily inspection reports shall be signed by the responsible QC technician and the CQCPA. The RPR shall be provided at least one copy of each daily inspection report on the work day following the day of record. When QC inspection and test results are recorded and transmitted electronically, the results must be archived.

b. Daily test reports. The Contractor shall be responsible for establishing a system that will record all QC test results. Daily test reports shall document the following information:

- (1) Technical specification item number and description
- (2) Test designation
- (3) Location
- (4) Date of test
- (5) Control requirements
- (6) Test results
- (7) Causes for rejection
- (8) Recommended remedial actions
- (9) Retests

Test results from each day's work period shall be submitted to the Construction Manager prior to the start of the next day's work period. When required by the technical specifications, the Contractor shall maintain statistical QC charts. When QC daily test results are recorded and transmitted electronically, the results must be archived.

100-10 CORRECTIVE ACTION REQUIREMENTS. The CQCP shall indicate the appropriate action to be taken when a process is deemed, or believed, to be out of control (out of tolerance) and detail what action will be taken to bring the process into control. The requirements for corrective action shall include both general requirements for operation of the CQCP as a whole, and for individual items of work contained in the technical specifications.

The CQCP shall detail how the results of QC inspections and tests will be used for determining the need for corrective action and shall contain clear rules to gauge when a process is out of control and the type of correction to be taken to regain process control.

When applicable or required by the technical specifications, the Contractor shall establish and use statistical QC charts for individual QC tests. The requirements for corrective action shall be linked to the control charts.

100-11 INSPECTION AND/OR OBSERVATIONS BY THE CONSTRUCTION MANAGER. All

items of material and equipment are subject to inspection and/or observation by the Construction Manager at the point of production, manufacture or shipment to determine if the Contractor, producer, manufacturer or shipper maintains an adequate QC system in conformance with the requirements detailed here and the applicable technical specifications and plans. In addition, all items of materials, equipment and work in place shall be subject to inspection and/or observation by the Construction Manager at the site for the same purpose.

Inspection and/or observations by the Construction Manager does not relieve the Contractor of performing QC inspections of either on-site or off-site Contractor's or subcontractor's work.

100-12 NONCOMPLIANCE.

a. The Construction Manager will provide written notice to the Contractor of any noncompliance with their CQCP. After receipt of such notice, the Contractor must take corrective action.

b. When QC activities do not comply with either the CQCP or the contract provisions or when the Contractor fails to properly operate and maintain an effective CQCP, and no effective corrective actions have been taken after notification of non-compliance, the Construction Manager will recommend the Owner take the following actions:

(1) Order the Contractor to replace ineffective or unqualified QC personnel or subcontractors and/or

(2) Order the Contractor to stop operations until appropriate corrective actions are taken.

METHOD OF MEASUREMENT

100-13 BASIS OF MEASUREMENT. There shall be no direct measurement for work under this item.

BASIS OF PAYMENT

100-14 Payment. There shall be no direct payment for work under this item. Payment for work under this item shall be considered under other items of similar work.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

National Institute for Certification in Engineering Technologies (NICET)

ASTM International (ASTM)

ASTM C1077	Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D3666	Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials

END OF ITEM C-100

ITEM C-102 TEMPORARY AIR AND WATER POLLUTION, SOIL EROSION, AND SILTATION CONTROL

DESCRIPTION

102-1. This item shall consist of temporary control measures as shown on the plans or as ordered by the Construction Manager during the life of a contract to control pollution of air and water, soil erosion, and siltation through the use of silt fences, berms, dikes, dams, sediment basins, fiber mats, gravel, mulches, grasses, slope drains, and other erosion control devices or methods.

Temporary erosion control shall be in accordance with the approved erosion control plan; the approved Construction Safety and Phasing Plan (CSPP) and AC 150/5370-2, *Operational Safety on Airports During Construction*. The temporary erosion control measures contained herein shall be coordinated with the permanent erosion control measures specified as part of this contract to the extent practical to assure economical, effective, and continuous erosion control throughout the construction period.

Temporary control may include work outside the construction limits such as borrow pit operations, equipment and material storage sites, waste areas, and temporary plant sites.

Temporary control measures shall be designed, installed and maintained to minimize the creation of wildlife attractants that have the potential to attract hazardous wildlife on or near public-use airports.

MATERIALS

102-2.2 MULCHES. Mulches may be hay, straw, fiber mats, netting, bark, wood chips, rock or other suitable material reasonably clean and free of noxious weeds and deleterious materials. Mulches shall not create a wildlife attractant.

102-2.3 SLOPE DRAINS. Slope drains may be constructed of pipe, fiber mats, rubble, concrete, asphalt, or other materials that will adequately control erosion.

102-2.4 SILT FENCE. Silt fence shall consist of polymeric filaments which are formed into a stable network such that filaments retain their relative positions. Synthetic filter fabric shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life. Silt fence shall meet the requirements of ASTM D6461.

<u>102-2.5 OTHER.</u> All other materials shall meet commercial grade standards and shall be approved by the Construction Manager before being incorporated into the project.

CONSTRUCTION REQUIREMENTS

102-3.1 GENERAL. In the event of conflict between these requirements and pollution control laws, rules, or regulations of other federal, state, or local agencies, the more restrictive laws, rules, or regulations shall apply.

The Construction Manager shall be responsible for assuring compliance to the extent that construction practices, construction operations, and construction work are involved.

102-3.2 SCHEDULE. Prior to the start of construction, the Contractor shall submit schedules in accordance with the approved Construction Safety and Phasing Plan (CSPP) and the plans for accomplishment of temporary and permanent erosion control work for clearing and grubbing; grading; construction; paving; and structures at watercourses. The Contractor shall also submit a proposed method of erosion and dust control on haul roads and borrow pits and a plan for disposal of waste materials. Work shall not be started until the erosion control schedules and methods of operation for the applicable construction have been accepted by the Construction Manager.

102-3.3 CONSTRUCTION DETAILS. The Contractor will be required to incorporate all permanent erosion control features into the project at the earliest practicable time as outlined in the plans and approved CSPP. Except where future construction operations will damage slopes, the Contractor shall perform mulching and other specified slope protection work in stages, as soon as substantial areas of exposed slopes can be made available. Temporary erosion and pollution control measures will be used to correct conditions that develop during construction that were not foreseen during the design stage; that are needed prior to installation of permanent control features; or that are needed temporarily to control erosion that develops during normal construction practices, but are not associated with permanent control features on the project.

Where erosion may be a problem, schedule and perform clearing operations so that grading operations and permanent erosion control features can follow immediately if project conditions permit. Temporary erosion control measures are required if permanent measures cannot immediately follow grading operations. The Construction Manager shall limit the area of clearing, excavation, borrow, and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish grading, mulching and other such permanent control measures current with the accepted schedule. If seasonal limitations make such coordination unrealistic, temporary erosion control measures shall be taken immediately to the extent feasible and justified as directed by the Construction Manager.

The Contractor shall provide immediate permanent or temporary pollution control measures to minimize contamination of adjacent streams or other watercourses, lakes, ponds, or other areas of water impoundment as directed by the Construction Manager. If temporary erosion and pollution control measures are required due to the Contractor's negligence, carelessness, or failure to install permanent controls as a part of the work as scheduled or directed by the Construction Manager, the work shall be performed by the Contractor and the cost shall be incidental to this item.

The Construction Manager may increase or decrease the area of erodible earth material that can be exposed at any time based on an analysis of project conditions.

The erosion control features installed by the Contractor shall be maintained by the Contractor during the construction period.

Provide temporary structures whenever construction equipment must cross watercourses at frequent intervals. Pollutants such as fuels, lubricants, bitumen, raw sewage, wash water from concrete mixing operations, and other harmful materials shall not be discharged into any waterways, impoundments or into natural or manmade channels.

102-3.4 INSTALLATION, MAINTENANCE AND REMOVAL OF SILT FENCE. Silt fences shall extend a minimum of 16 inches (41 cm) and a maximum of 34 inches (86 cm) above the ground surface. Posts shall be set no more than 10 feet (3 m) on center. Filter fabric shall be cut from a continuous roll to the length required minimizing joints where possible. When joints are necessary, the fabric shall be spliced at a support post with a minimum 12-inch (300-mm) overlap and securely sealed. A trench shall be excavated approximately 4 inches (100 mm) deep by 4 inches (100 mm) wide on the upslope side of the silt fence. The trench shall be backfilled and the soil compacted over the silt fence fabric. The Contractor

shall remove and dispose of silt that accumulates during construction and prior to establishment of permanent erosion control. The fence shall be maintained in good working condition until permanent erosion control is established. Silt fence shall be removed upon approval of the Construction Manager.

METHOD OF MEASUREMENT

102-4.1 There shall be no direct measurement for work performed under this item.

BASIS OF PAYMENT

102-5.1 There shall be no direct payment for work performed under this item. Payment for work under this item shall be considered under other similar items of work.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Advisory Circulars (AC)

ction

ASTM D6461 Standard Specification for Silt Fence Materials

United States Department of Agriculture (USDA)

FAA/USDA Wildlife Hazard Management at Airports, A Manual for Airport Personnel

END OF ITEM C-102

ITEM C-105 MOBILIZATION

105-1 Description. This item of work shall consist of, but is not limited to, work and operations necessary for the movement of personnel, equipment, material and supplies to and from the project site for work on the project except as provided in the contract as separate pay items.

105-2 Mobilization limit. Mobilization shall be limited to 7 percent of the total project cost.

105-3 Posted notices. Prior to commencement of construction activities, the Contractor must post the following documents in a prominent and accessible place where they may be easily viewed by all employees of the prime Contractor and by all employees of subcontractors engaged by the prime Contractor: Equal Employment Opportunity (EEO) Poster "Equal Employment Opportunity is the Law" in accordance with the Office of Federal Contract Compliance Programs Executive Order 11246, as amended; Davis Bacon Wage Poster (WH 1321) - DOL "Notice to All Employees" Poster; and Applicable Davis-Bacon Wage Rate Determination. These notices must remain posted until final acceptance of the work by the Owner.

METHOD OF MEASUREMENT

105-5 Basis of measurement and payment. Based upon the contract lump sum price for "Mobilization" partial payments will be allowed as follows:

- **a.** With first pay request, 25%.
- **b.** When 25% or more of the original contract is earned, an additional 25%.
- c. When 50% or more of the original contract is earned, an additional 40%.

d. After Final Inspection, Staging area clean-up and delivery of all Project Closeout materials as required by Section 90, paragraph 90-11, *Contractor Final Project Documentation*, the final 10%.

e. Payment for "Demobilization and Remobilization for Winter Shutdown" shall be made at the contract lump sum price. This item shall include full compensation for demobilization and remobilization associated with the owner executing a winter shutdown period and shall include all equipment, airport safety and security elements, temporary construction phasing items and any other incidentals associated with a winter shutdown of construction and returning the airfield to operational condition per FAA requirements. No additional compensation will be made for additional work associated with a winter shutdown period.

BASIS OF PAYMENT

105-6 Payment will be made under:

- Item C-105-1 Mobilization
- Item C-105-2 Demobilization and Remobilization for Winter Shutdown

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Office of Federal Contract Compliance Programs (OFCCP)

Executive Order 11246, as amended

EEOC-P/E-1 – Equal Employment Opportunity is the Law Poster

United States Department of Labor, Wage and Hour Division (WHD)

WH 1321 - Employee Rights under the Davis-Bacon Act Poster

END OF ITEM C-105

ITEM C-106 AIRPORT SAFETY & SECURITY DESCRIPTION

<u>106-1</u> This specification outlines safety procedures and regulations to be followed by the Contractor during the course of this work. The work item "Airport Safety and Security" shall consist of furnishing, installing, and removing temporary marking, signing, lighting, and barricades required during the course of this worked to conform with FAA Advisory Circular 150/5370-2G "Operational Safety on Airports During Construction." It shall also include furnishing sufficient flaggers, vacuum trucks, pilot cars and other required items for traffic control throughout the duration of the project. The Contractor shall be required to submit a Safety Plan to the Owner and have it approved prior to beginning construction activities.

<u>Regulations for Contractors in Operating Areas</u> – For the purpose and intent of these regulations, flight operation areas are construed to mean all areas restricted to public access on the field. The airport will remain in operation during the course of the contract work. The following operating regulations shall be adhered to at all times. The contractor shall indoctrinate all of his personnel and subcontractors on these regulations.

- Prior to commencement of the work on any portion of the project, the Contractor shall schedule a
 meeting with the Construction Manager and Airside Operations to discuss and interview the personnel
 planned to operate any and all pilot vehicles and vacuum trucks during the course of construction. <u>The
 drivers must have a valid driver's license, may be subject to RTAA screening/background check, and
 must undergo training with the RTAA.</u> The Contractor should allow a minimum of one day for this
 training. If the Construction Manager or the RTAA deems any one driver to not meet expectations for
 driving within the airports area, they shall be replaced immediately with another driver that has met all
 the same criteria. The RTAA representative will have final approval authority of the selected driver(s).
 If the driver(s) does meet RTAA standards, they will not be allowed to operate a pilot vehicle or vacuum
 truck during the course of construction. <u>To the extent possible the driver(s) shall remain the same
 during the course of construction.</u>
- 2. Absolutely no access to the Airport will be allowed without an active pilot vehicle, gate guard, flagger and other security measures as described within this specification and as deemed appropriate by the airport and Construction Manager.
- 3. Prior to the commencement of any work within the project area, the Contractor must provide flaggers in the areas shown within the plans or as directed by the Construction Manager. <u>The flaggers within the airport project area must be approved by the RTAA and the Construction Manager</u>. <u>Each flagger must undergo a minimum of a 2-hour orientation class with the RTAA</u>. If the Construction Manager of the Airport deems any one flagger to not meet expectations for flagging within the airports terminal area, they shall be replaced immediately with another flagger that has met all the same criteria. To the extent possible the immediately with another flagger that has met all the same criteria. To the extent possible the flaggers shall remain the same during the course of the project.
- 4. Should a winter shutdown occur, after the winter shut down and prior to starting construction again in the spring, the pilot vehicle and vacuum truck driver(s), flaggers and gate guards must attend a 2-hour orientation meeting to reaffirm their aptitude regardless of their previous work.
- 5. Prior to commencement of the work on any of the project area, the Contractor and the Construction Manager will review the select haul routes to be used by personnel and vehicles during the course of the work in various stages as shown within the drawings. The Contractor shall furnish, install, and maintain

appropriate flaggers, traffic signs, barricades and pilot cars that clearly identify a haul route throughout its length within the flight operation area.

- **6.** FAA approved orange and white-checkered flags or omni-directional amber flashing lights shall be provided by the Contractor on all vehicles and equipment.
- 7. During night operations, each vehicle shall be equipped with omni-directional amber flashing light mounted on the roof of the cab. Headlights, taillights, and flashers shall be used for all activities during these hours. FAA approved orange and white-checkered flags will not be sufficient during night hours when operating inside of the Airport fence.
- 8. No construction activity will be allowed within 250 feet of the centerline of any active runway, within 110 feet of the centerline of an active taxiway or within 25 feet of parked aircraft without prior approval. The contractor shall notify the Construction Manager at least 48 hours prior to any need to do work inside these limits so that necessary notices or closures can be made. The Airport Authority will issue airport closures (NOTAMS).
- 9. No vehicles shall pass in front of taxiing aircraft or emergency vehicles at any time.
- **10.** The flight operation area is immediately adjacent to the designated construction area. Activities beyond the construction limits will require prior clearance.
- **11.** Construction equipment that extends 15 feet or more above ground level shall be cleared through the Construction Manager. It shall be lighted at night in an approved manner and/or lowered to the height of adjacent structural surroundings at the discretion of the Engineer.
- 12. Welding equipment shall not be used within 100 feet of fuel trucks or aircraft.
- **13.** All accidents shall be reported to the Construction Manager.
- **14.** In the event of an airport emergency, men and equipment shall be moved immediately at the direction of the Construction Manager or Owner.
- **15.** <u>The Contractor shall be responsible for ensuring that the construction area is kept free of construction debris, equipment, and/or materials that might endanger or be ingested by an aircraft.</u>
- **16.** The Contractor is required to provide a vacuum truck in any and all areas that construction activities commingle with aircraft or other vehicles within airport property. The vacuum truck shall be manned at all times during construction activity. The construction area shall be kept clean at all times.
- **17.** The Contractor's Flaggers shall be equipped with Contractor supplied hand held ICOM A6 Air Band Transceivers model A16, or approved equal, capable of monitoring ground and tower frequencies.
- 18. Contractor's access to the site shall be as shown on the plans. No other access points shall be allowed unless approved by the Construction Manager. Contractor's traffic authorized to enter the site shall be experienced in the route or guided by contractor personnel. The contractor shall be responsible for traffic control to and from the various constructions areas on the airport property. The contractor is responsible for <u>immediate</u> clean-up of any debris deposited along the delivery route to the storage area or work site shall be as directed by the Contraction Manger.

19. The Contractor shall notify the Engineer at least 48 hours in advance of the need to enter the Airport area. Absolutely no access to the Airport will be given without prior consent. Delays to construction due to access restrictions will not be just cause for contract time extensions.

EQUIPMENT AND MATERIALS

<u>106-2.1 CONSTRUCTION SAFETY AND PHASING PLAN (CSPP)</u>. The contractor's attention is drawn towards Special Provision No. 11 as well as the Construction Safety and Phasing Plan included within Volume III of these project documents. The contractor shall prepare their own Safety Plan Compliance Document in accordance with these documents for submission and approval by the Engineer. The project specific SPCD prepared by the contractor shall be submitted and approved prior to contractors access being granted to the project site.

106-2.2 BARRICADES. Lighted low-level barricades marked with diagonal, alternating orange and white stripes shall be provided by the contractor and placed <u>continuously</u> as shown within plans and as directed by the Construction Manager. All low-level barricades shall have at least one steady burning <u>red</u> light affixed to one of the ends. Orange lights will not be allowed. All barricades shall be firmly anchored against overturning and displacement from wind, jetblast, or propwash. Should the Contractor need barrier rail within the construction zone, it shall be provided and removed by the Contractor. No direct payment will be made for flashing barricades or other types of barrier rail as described or for labor, equipment, and materials necessary to install them.

106-2.3 TEMPORARY MARKING AND SIGNING. The Contractor shall install temporary signs, lights, traffic control devices, and other temporary markings other than striping required during the course of this contract. The temporary marking shall conform to applicable Federal Aviation Administration markings and shall be constructed of materials approved by the Engineer.

106-2.4 TEMPORARY COVERING OF SIGNS AND LIGHTING. The Contractor shall cover existing lights and signs as directed by the plans, Airport Operations, or the Construction Manager to facilitate temporary closures of runway, taxiways, or other areas. Temporary covers shall ensure illuminated signs and lights are not visible to taxiing aircraft during low light hours. Furthermore, all temporary covers shall be secured in a manor as to not cause a hazard to aircraft during periods of high wind.

It is incumbent on the Contractor to consider these costs as they relate to his phasing plan and durations.

MEASUREMENT AND PAYMENT

106-3.1. The accepted pay quantity for "Airport Safety and Security" will be paid for at the lump sum contract unit price stated in the proposal. This price shall be full compensation including Contractor overhead and profit for furnishing flaggers, escorts, radios, barricades, lights, temporary gates, temporary fencing, and other temporary markings as well as maintenance of those items during the duration of the project and for all labor, equipment tools and incidentals necessary to complete the item. This item shall be continued until such time as the Contractor has completed the contract to the satisfaction of the Engineer. The payment for this item shall not exceed the original contract time unless otherwise approved by the Engineer.

Payment will be made under:

Item C-106-1 Airport Safety and Security – lump sum

END OF ITEM C-106

ITEM C-110 METHOD OF ESTIMATING PERCENTAGE OF MATERIAL WITHIN SPECIFICATION LIMITS (PWL)

110-1 General. When the specifications provide for acceptance of material based on the method of estimating percentage of material within specification limits (PWL), the PWL will be determined in accordance with this section. All test results for a lot will be analyzed statistically to determine the total estimated percent of the lot that is within specification limits. The PWL is computed using the sample average (X) and sample standard deviation (S_n) of the specified number (n) of sublots for the lot and the specification tolerance limits, L for lower and U for upper, for the particular acceptance parameter. From these values, the respective Quality index, Q_L for Lower Quality Index and/or Q_U for Upper Quality Index, is computed and the PWL for the lot for the specified n is determined from Table 1. All specification limits specified in the technical sections shall be absolute values. Test results used in the calculations shall be to the significant figure given in the test procedure.

There is some degree of uncertainty (risk) in the measurement for acceptance because only a small fraction of production material (the population) is sampled and tested. This uncertainty exists because all portions of the production material have the same probability to be randomly sampled. The Contractor's risk is the probability that material produced at the acceptable quality level is rejected or subjected to a pay adjustment. The Owner's risk is the probability that material produced at the rejectable quality level is accepted.

It is the intent of this section to inform the Contractor that, in order to consistently offset the Contractor's risk for material evaluated, production quality (using population average and population standard deviation) must be maintained at the acceptable quality specified or higher. In all cases, it is the responsibility of the Contractor to produce at quality levels that will meet the specified acceptance criteria when sampled and tested at the frequencies specified.

110-2 Method for computing PWL. The computational sequence for computing PWL is as follows:

a. Divide the lot into n sublots in accordance with the acceptance requirements of the specification.

b. Locate the random sampling position within the sublot in accordance with the requirements of the specification.

c. Make a measurement at each location, or take a test portion and make the measurement on the test portion in accordance with the testing requirements of the specification.

d. Find the sample average (X) for all sublot test values within the lot by using the following formula:

$\mathbf{X} = (\mathbf{x}_1 + \mathbf{x}_2 + \mathbf{x}_3 + \dots \mathbf{x}_n) / \mathbf{n}$

Where: X = Sample average of all sublot test values within a lot

 $x_1, x_2, \ldots x_n$ = Individual sublot test values

n = Number of sublot test values

e. Find the sample standard deviation (S_n) by use of the following formula:

$$S_n = [(d_1^2 + d_2^2 + d_3^2 + \dots + d_n^2)/(n-1)]^{1/2}$$

Where: $S_n =$ Sample standard deviation of the number of sublot test values in the set

 $d_1, d_2, \dots d_n$ = Deviations of the individual sublot test values x_1, x_2, \dots from the average value X

that is: $d_1 = (x_1 - X), d_2 = (x_2 - X) \dots d_n = (x_n - X)$

n = Number of sublot test values

f. For single sided specification limits (i.e., L only), compute the Lower Quality Index Q_L by use of the following formula:

$\mathbf{Q}_{\mathrm{L}} = (\mathbf{X} - \mathbf{L}) / \mathbf{S}_{\mathrm{n}}$

Where: L = specification lower tolerance limit

Estimate the percentage of material within limits (PWL) by entering Table 1 with Q_L , using the column appropriate to the total number (n) of measurements. If the value of Q_L falls between values shown on the table, use the next higher value of PWL.

g. For double-sided specification limits (i.e., L and U), compute the Quality Indexes Q_L and Q_U by use of the following formulas:

$$Q_{L} = (X - L) / S_{n}$$

and
$$Q_{U} = (U - X) / S_{n}$$

Where: L and U = specification lower and upper tolerance limits

Estimate the percentage of material between the lower (L) and upper (U) tolerance limits (PWL) by entering Table 1 separately with Q_L and Q_U , using the column appropriate to the total number (n) of measurements, and determining the percent of material above P_L and percent of material below P_U for each tolerance limit. If the values of Q_L fall between values shown on the table, use the next higher value of P_L or P_U . Determine the PWL by use of the following formula:

$PWL = (P_U + P_L) - 100$

Where: P_L = percent within lower specification limit P_U = percent within upper specification limit

EXAMPLE OF PWL CALCULATION

Project: Example Project

Test Item: Item P-401, Lot A.

A. PWL Determination for Mat Density.

1. Density of four random cores taken from Lot A.

A-1 = 96.60A-2 = 97.55A-3 = 99.30A-4 = 98.35n = 4

2. Calculate average density for the lot.

$$\mathbf{X} = (\mathbf{x}_1 + \mathbf{x}_2 + \mathbf{x}_3 + \dots + \mathbf{x}_n) / n$$

$$X = (96.60 + 97.55 + 99.30 + 98.35) / 4$$

X = 97.95% density

3. Calculate the standard deviation for the lot.

$$\begin{split} S_n &= \left[\left((96.60 - 97.95)^2 + (97.55 - 97.95)^2 + (99.30 - 97.95)^2 + (98.35 - 97.95)^2 \right) \right) / (4 - 1) \right]^{1/2} \\ S_n &= \left[(1.82 + 0.16 + 1.82 + 0.16) / 3 \right]^{1/2} \\ S_n &= 1.15 \end{split}$$

4. Calculate the Lower Quality Index Q_L for the lot. (L=96.3)

.15

$$Q_L = (X - L) / S_n$$

 $Q_L = (97.95 - 96.30) / 1$
 $O_L = 1.4348$

5. Determine PWL by entering Table 1 with Q_L = 1.44 and n= 4. PWL = 98

B. PWL Determination for Air Voids.

- **1.** Air Voids of four random samples taken from Lot A.
 - A-1 = 5.00A-2 = 3.74A-3 = 2.30A-4 = 3.25
- 2. Calculate the average air voids for the lot.
 - $X = (x_1 + x_2 + x_3 \dots n) / n$ X = (5.00 + 3.74 + 2.30 + 3.25) / 4X = 3.57%
- **3.** Calculate the standard deviation S_n for the lot.
 - $$\begin{split} S_n &= \left[\left((3.57 5.00)^2 + (3.57 3.74)^2 + (3.57 2.30)^2 + (3.57 3.25)^2 \right) / (4 1) \right]^{1/2} \\ S_n &= \left[\left(2.04 + 0.03 + 1.62 + 0.10 \right) / 3 \right]^{1/2} \\ S_n &= 1.12 \end{split}$$
- **4.** Calculate the Lower Quality Index Q_L for the lot. (L= 2.0)

 $Q_L = (X - L) / S_n$ $Q_L = (3.57 - 2.00) / 1.12$ $Q_L = 1.3992$

- 5. Determine P_L by entering Table 1 with $Q_L = 1.41$ and n = 4. $P_L = 97$
- **6.** Calculate the Upper Quality Index Q_U for the lot. (U= 5.0)

 $Q_{U} = (U - X) / S_{n}$ $Q_{U} = (5.00 - 3.57) / 1.12$ $Q_{U} = 1.2702$

- 7. Determine P_U by entering Table 1 with $Q_U = 1.29$ and n = 4.
 - $P_{\rm U} = 93$
- 8. Calculate Air Voids PWL
 - $PWL = (P_L + P_U) 100$

EXAMPLE OF OUTLIER CALCULATION (REFERENCE ASTM E178)

Project: Example Project

Test Item: Item P-401, Lot A.

A. Outlier Determination for Mat Density.

1. Density of four random cores taken from Lot A arranged in descending order.

A-3 = 99.30A-4 = 98.35

A-2 = 97.55

A-1 = 96.60

2. From ASTM E178, Table 1, for n=4 an upper 5% significance level, the critical value for test criterion = 1.463.

3. Use average density, standard deviation, and test criterion value to evaluate density measurements.

a. For measurements greater than the average:

If (measurement - average)/(standard deviation) is less than test criterion, then the measurement is not considered an outlier.

For A-3, check if (99.30 - 97.95) / 1.15 is greater than 1.463.

Since 1.174 is less than 1.463, the value is not an outlier.

b. For measurements less than the average:

If (average - measurement)/(standard deviation) is less than test criterion, then the measurement is not considered an outlier.

For A-1, check if (97.95 - 96.60) / 1.15 is greater than 1.463.

Since 1.435 is less than 1.463, the value is not an outlier.

Note: In this example, a measurement would be considered an outlier if the density were:

Greater than $(97.95 + 1.463 \times 1.15) = 99.63\%$

OR

less than $(97.95 - 1.463 \times 1.15) = 96.27\%$.

Table 1. Table for Estimating Percent of Lot Within Limits (P	WL)
---	-----

Percent Within	Positive Values of Q (QL and QU)							
Limits (PL and PU)	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
99	1.1541	1.4700	1.6714	1.8008	1.8888	1.9520	1.9994	2.0362
98	1.1524	1.4400	1.6016	1.6982	1.7612	1.8053	1.8379	1.8630
97	1.1496	1.4100	1.5427	1.6181	1.6661	1.6993	1.7235	1.7420
96	1.1456	1.3800	1.4897	1.5497	1.5871	1.6127	1.6313	1.6454
95	1.1405	1.3500	1.4407	1.4887	1.5181	1.5381	1.5525	1.5635
94	1.1342	1.3200	1.3946	1.4329	1.4561	1.4717	1.4829	1.4914
93	1.1269	1.2900	1.3508	1.3810	1.3991	1.4112	1.4199	1.4265
92	1.1184	1.2600	1.3088	1.3323	1.3461	1.3554	1.3620	1.3670
91	1.1089	1.2300	1.2683	1.2860	1.2964	1.3032	1.3081	1.3118
90	1.0982	1.2000	1.2290	1.2419	1.2492	1.2541	1.2576	1.2602
89	1.0864	1.1700	1.1909	1.1995	1.2043	1.2075	1.2098	1.2115
88	1.0736	1.1400	1.1537	1.1587	1.1613	1.1630	1.1643	1.1653

Percent Within	Positive Values of Q (Q _L and Q _U)							
Limits (PL and PU)	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
87	1.0597	1.1100	1.1173	1.1192	1.1199	1.1204	1.1208	1.1212
86	1.0448	1.0800	1.0817	1.0808	1.0800	1.0794	1.0791	1.0789
85	1.0288	1.0500	1.0467	1.0435	1.0413	1.0399	1.0389	1.0382
84	1.0119	1.0200	1.0124	1.0071	1.0037	1.0015	1.0000	0.9990
83	0.9939	0.9900	0.9785	0.9715	0.9671	0.9643	0.9624	0.9610
82	0.9749	0.9600	0.9452	0.9367	0.9315	0.9281	0.9258	0.9241
81	0.9550	0.9300	0.9123	0.9025	0.8966	0.8928	0.8901	0.8882
80	0.9342	0.9000	0.8799	0.8690	0.8625	0.8583	0.8554	0.8533
79	0.9124	0.8700	0.8478	0.8360	0.8291	0.8245	0.8214	0.8192
78	0.8897	0.8400	0.8160	0.8036	0.7962	0.7915	0.7882	0.7858
77	0.8662	0.8100	0.7846	0.7716	0.7640	0.7590	0.7556	0.7531
76	0.8417	0.7800	0.7535	0.7401	0.7322	0.7271	0.7236	0.7211
75	0.8165	0.7500	0.7226	0.7089	0.7009	0.6958	0.6922	0.6896
74	0.7904	0.7200	0.6921	0.6781	0.6701	0.6649	0.6613	0.6587
73	0.7636	0.6900	0.6617	0.6477	0.6396	0.6344	0.6308	0.6282
72	0.7360	0.6600	0.6316	0.6176	0.6095	0.6044	0.6008	0.5982
71	0.7077	0.6300	0.6016	0.5878	0.5798	0.5747	0.5712	0.5686
70	0.6787	0.6000	0.5719	0.5582	0.5504	0.5454	0.5419	0.5394
69	0.6490	0.5700	0.5423	0.5290	0.5213	0.5164	0.5130	0.5105
68	0.6187	0.5400	0.5129	0.4999	0.4924	0.4877	0.4844	0.4820
67	0.5878	0.5100	0.4836	0.4710	0.4638	0.4592	0.4560	0.4537
66	0.5563	0.4800	0.4545	0.4424	0.4355	0.4310	0.4280	0.4257
65	0.5242	0.4500	0.4255	0.4139	0.4073	0.4030	0.4001	0.3980
64	0.4916	0.4200	0.3967	0.3856	0.3793	0.3753	0.3725	0.3705
63	0.4586	0.3900	0.3679	0.3575	0.3515	0.3477	0.3451	0.3432
62	0.4251	0.3600	0.3392	0.3295	0.3239	0.3203	0.3179	0.3161
61	0.3911	0.3300	0.3107	0.3016	0.2964	0.2931	0.2908	0.2892
60	0.3568	0.3000	0.2822	0.2738	0.2691	0.2660	0.2639	0.2624
59	0.3222	0.2700	0.2537	0.2461	0.2418	0.2391	0.2372	0.2358
58	0.2872	0.2400	0.2254	0.2186	0.2147	0.2122	0.2105	0.2093
57	0.2519	0.2100	0.1971	0.1911	0.1877	0.1855	0.1840	0.1829
56	0.2164	0.1800	0.1688	0.1636	0.1607	0.1588	0.1575	0.1566
55	0.1806	0.1500	0.1406	0.1363	0.1338	0.1322	0.1312	0.1304
54	0.1447	0.1200	0.1125	0.1090	0.1070	0.1057	0.1049	0.1042
53	0.1087	0.0900	0.0843	0.0817	0.0802	0.0793	0.0786	0.0781
52	0.0725	0.0600	0.0562	0.0544	0.0534	0.0528	0.0524	0.0521
51	0.0363	0.0300	0.0281	0.0272	0.0267	0.0264	0.0262	0.0260
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Percent	Negative Values of Q (Q _L and Q _U)							
Within Limits	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
(P _L and P _U)								
49	-0.0363	-0.0300	-0.0281	-0.0272	-0.0267	-0.0264	-0.0262	-0.0260
48	-0.0725	-0.0600	-0.0562	-0.0544	-0.0534	-0.0528	-0.0524	-0.0521
47	-0.1087	-0.0900	-0.0843	-0.0817	-0.0802	-0.0793	-0.0786	-0.0781
46	-0.1447	-0.1200	-0.1125	-0.1090	-0.1070	-0.1057	-0.1049	-0.1042
45	-0.1806	-0.1500	-0.1406	-0.1363	-0.1338	-0.1322	-0.1312	-0.1304
44	-0.2164	-0.1800	-0.1688	-0.1636	-0.1607	-0.1588	-0.1575	-0.1566
43	-0.2519	-0.2100	-0.1971	-0.1911	-0.1877	-0.1855	-0.1840	-0.1829
42	-0.2872	-0.2400	-0.2254	-0.2186	-0.2147	-0.2122	-0.2105	-0.2093
41	-0.3222	-0.2700	-0.2537	-0.2461	-0.2418	-0.2391	-0.2372	-0.2358
40	-0.3568	-0.3000	-0.2822	-0.2738	-0.2691	-0.2660	-0.2639	-0.2624
39	-0.3911	-0.3300	-0.3107	-0.3016	-0.2964	-0.2931	-0.2908	-0.2892
38	-0.4251	-0.3600	-0.3392	-0.3295	-0.3239	-0.3203	-0.3179	-0.3161
37	-0.4586	-0.3900	-0.3679	-0.3575	-0.3515	-0.3477	-0.3451	-0.3432
36	-0.4916	-0.4200	-0.3967	-0.3856	-0.3793	-0.3753	-0.3725	-0.3705

Percent	Negative Values of Q (Q _L and Q _U)								
Within Limits	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	
(P _L and P _U)									
35	-0.5242	-0.4500	-0.4255	-0.4139	-0.4073	-0.4030	-0.4001	-0.3980	
34	-0.5563	-0.4800	-0.4545	-0.4424	-0.4355	-0.4310	-0.4280	-0.4257	
33	-0.5878	-0.5100	-0.4836	-0.4710	-0.4638	-0.4592	-0.4560	-0.4537	
32	-0.6187	-0.5400	-0.5129	-0.4999	-0.4924	-0.4877	-0.4844	-0.4820	
31	-0.6490	-0.5700	-0.5423	-0.5290	-0.5213	-0.5164	-0.5130	-0.5105	
30	-0.6787	-0.6000	-0.5719	-0.5582	-0.5504	-0.5454	-0.5419	-0.5394	
29	-0.7077	-0.6300	-0.6016	-0.5878	-0.5798	-0.5747	-0.5712	-0.5686	
28	-0.7360	-0.6600	-0.6316	-0.6176	-0.6095	-0.6044	-0.6008	-0.5982	
27	-0.7636	-0.6900	-0.6617	-0.6477	-0.6396	-0.6344	-0.6308	-0.6282	
26	-0.7904	-0.7200	-0.6921	-0.6781	-0.6701	-0.6649	-0.6613	-0.6587	
25	-0.8165	-0.7500	-0.7226	-0.7089	-0.7009	-0.6958	-0.6922	-0.6896	
24	-0.8417	-0.7800	-0.7535	-0.7401	-0.7322	-0.7271	-0.7236	-0.7211	
23	-0.8662	-0.8100	-0.7846	-0.7716	-0.7640	-0.7590	-0.7556	-0.7531	
22	-0.8897	-0.8400	-0.8160	-0.8036	-0.7962	-0.7915	-0.7882	-0.7858	
21	-0.9124	-0.8700	-0.8478	-0.8360	-0.8291	-0.8245	-0.8214	-0.8192	
20	-0.9342	-0.9000	-0.8799	-0.8690	-0.8625	-0.8583	-0.8554	-0.8533	
19	-0.9550	-0.9300	-0.9123	-0.9025	-0.8966	-0.8928	-0.8901	-0.8882	
18	-0.9749	-0.9600	-0.9452	-0.9367	-0.9315	-0.9281	-0.9258	-0.9241	
17	-0.9939	-0.9900	-0.9785	-0.9715	-0.9671	-0.9643	-0.9624	-0.9610	
16	-1.0119	-1.0200	-1.0124	-1.0071	-1.0037	-1.0015	-1.0000	-0.9990	
15	-1.0288	-1.0500	-1.0467	-1.0435	-1.0413	-1.0399	-1.0389	-1.0382	
14	-1.0448	-1.0800	-1.0817	-1.0808	-1.0800	-1.0794	-1.0791	-1.0789	
13	-1.0597	-1.1100	-1.1173	-1.1192	-1.1199	-1.1204	-1.1208	-1.1212	
12	-1.0736	-1.1400	-1.1537	-1.1587	-1.1613	-1.1630	-1.1643	-1.1653	
11	-1.0864	-1.1700	-1.1909	-1.1995	-1.2043	-1.2075	-1.2098	-1.2115	
10	-1.0982	-1.2000	-1.2290	-1.2419	-1.2492	-1.2541	-1.2576	-1.2602	
9	-1.1089	-1.2300	-1.2683	-1.2860	-1.2964	-1.3032	-1.3081	-1.3118	
8	-1.1184	-1.2600	-1.3088	-1.3323	-1.3461	-1.3554	-1.3620	-1.3670	
7	-1.1269	-1.2900	-1.3508	-1.3810	-1.3991	-1.4112	-1.4199	-1.4265	
6	-1.1342	-1.3200	-1.3946	-1.4329	-1.4561	-1.4717	-1.4829	-1.4914	
5	-1.1405	-1.3500	-1.4407	-1.4887	-1.5181	-1.5381	-1.5525	-1.5635	
4	-1.1456	-1.3800	-1.4897	-1.5497	-1.5871	-1.6127	-1.6313	-1.6454	
3	-1.1496	-1.4100	-1.5427	-1.6181	-1.6661	-1.6993	-1.7235	-1.7420	
2	-1.1524	-1.4400	-1.6016	-1.6982	-1.7612	-1.8053	-1.8379	-1.8630	
1	-1.1541	-1.4700	-1.6714	-1.8008	-1.8888	-1.9520	-1.9994	-2.0362	

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM E178

Standard Practice for Dealing with Outlying Observations

END OF ITEM C-110

Item P-101 Preparation/Removal of Existing Pavements

DESCRIPTION

<u>101-1</u> This item shall consist of preparation of existing pavement surfaces for overlay, surface treatments, removal of existing pavement, and other miscellaneous items. The work shall be accomplished in accordance with these specifications and the applicable plans.

EQUIPMENT AND MATERIALS

<u>101-2</u> All equipment and materials shall be specified here and in the following paragraphs or approved by the Construction Manager. The equipment shall not cause damage to the pavement to remain in place.

CONSTRUCTION

101-3.2 REMOVAL OF EXISTING PAVEMENT.

The Contractor's removal operation shall be controlled to not damage adjacent pavement structure, and base material, cables, utility ducts, pipelines, or drainage structures which are to remain under the pavement.

a. Concrete pavement removal. Full depth saw cuts shall be made perpendicular to the slab surface. The Contractor shall saw through the full depth of the slab including any dowels at the joint, removing the pavement and installing new dowels as shown on the plans and per the specifications. Where the perimeter of the removal limits is not located on the joint and there are no dowels present, the perimeter shall be saw cut the full depth of the pavement. The pavement inside the saw cut shall be removed by methods which will not cause distress in the pavement which is to remain in place. Concrete pavements shall be sawn full depth with a double sawcut prior to demolition adjacent to any pavement to remain. Concrete slabs that are damaged by under breaking shall be repaired or removed and replaced as directed by the Engineer.

The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Spall and underbreak repair shall be in accordance with the plans. Any underlaying material that is to remain in place, shall be recompacted and/or replaced as shown on the plans. Adjacent areas damaged during repair shall be repaired or replaced at the Contractor's expense.

b. Asphalt pavement removal. Asphalt pavement to be removed shall be cut to the full depth of the asphalt pavement around the perimeter of the area to be removed. If the material is to be utilized onsite or to be stockpiled onsite for Owners use as bituminous millings, it shall be removed by cold milling or post-processed to produce a material with a maximum size of 1-1/2 inches.

Pavement shall be removed to full depth. Pavement shall be removed so the joint for each layer of the pavement replacement is offset 1 foot from the joint of the proceeding layer.

Contractor shall refer to the Geotechnical Investigation for known pavement thickness. Contractor shall note that actual pavement thickness may exceed those values noted in the geotechnical investigation. There will be no additional compensation for additional pavement removal in excess of values noted on the plans or Geotechnical Investigation.

c. Repair or removal of Base, Subbase, and/or Subgrade. All failed material including surface, base course, subbase course, and subgrade shall be removed and repaired as shown on the plans or as directed by the Construction Manager. Materials and methods of construction shall comply with the applicable sections of these specifications. Any damage caused by Contractor's removal process shall be repaired at the Contractor's expense.

<u>101-3.2 PREPARATION OF JOINTS AND CRACKS PRIOR TO OVERLAY/SURFACE</u> <u>TREATMENT.</u>

Not used.

101-3.3 REMOVAL OF FOREIGN SUBSTANCES/CONTAMINATES PRIOR TO REMARKING.

Removal of foreign substances/contaminates from existing pavement that will affect the bond of the new treatment shall consist of removal of rubber, fuel spills, oil, crack sealer, at least 100% of paint, and other foreign substances from the surface of the pavement. Areas that require removal are designated on the plans and as directed by the Construction Manager in the field during construction.

Water blasting or other approved methods may be used for striping removal. Removal methods used shall not cause major damage to the pavement, or to any structure or utility within or adjacent to the work area. Major damage is defined as changing the properties of the pavement, removal of asphalt causing the aggregate to ravel, or removing pavement over 1/8 inch (3 mm) deep. If it is deemed by the Construction Manager that damage to the existing pavement is caused by operational error, such as permitting the application method to dwell in one location for too long, the Contractor shall repair the damaged area without compensation and as directed by the Construction Manager.

Removal of foreign substances shall not proceed until approved by the Construction Manager. Water used for high-pressure water equipment shall be provided by the Contractor at the Contractor's expense. No material shall be deposited on the pavement shoulders. All wastes shall be disposed of in areas indicated in this specification or shown on the plans.

101-3.4 CONCRETE SPALL OR FAILED ASPHALTIC CONCRETE PAVEMENT REPAIR.

- **a. Repair of concrete spalls.** The Contractor shall repair all spalled concrete as specified in section P-501 and P-607.
- **b.** Asphalt pavement repair. Not used.

101-3.5 COLD MILLING. Milling shall be performed with a power-operated milling machine or grinder, capable of producing a uniform finished surface. The milling machine or grinder shall operate without tearing or gouging the underlaying surface. The milling machine or grinder shall be equipped with grade and slope controls, and a positive means of dust control. All millings shall be removed and disposed off airport property, unless otherwise specified. If the Contractor mills or grinds deeper or wider than the plans specify, the Contractor shall replace the material removed with new material at the Contractor's Expense.

a. Patching. The milling machine shall be capable of cutting a vertical edge without chipping or spalling the edges of the remaining pavement and it shall have a positive method of controlling the depth of cut. The Construction Manager shall layout the area to be milled with a straightedge in increments of 1-foot (30 cm) widths. The area to be milled shall cover only the failed area. Any excessive area that is milled because the Contractor doesn't have the appropriate milling machine, or areas that are damaged because of his negligence, shall be repaired by the Contractor at the Contractor's Expense.

- **b. Profiling, grade correction, or surface correction.** The milling machine shall have a minimum width of 7 feet and it shall be equipped with electronic grade control devices that will cut the surface to the grade specified. The tolerances shall be maintained within +0 inch and -1/4 inch (+0 mm and -6mm) of the specified grade. The machine must cut vertical edges and have a positive method of dust control. All millings shall be removed and disposed of off airport property.
- c. Clean-up. The Contractor shall sweep the milled surface daily and immediately after the milling until all residual materials are removed from the pavement surface. Waste materials shall be collected and removed from the pavement surface and adjacent areas by sweeping or vacuuming. Waste materials shall be removed and disposed of off airport property, unless otherwise specified.

101-3.6. Preparation of asphalt pavement surfaces prior to surface treatment. Not used.

101-3.7 MAINTENANCE. The Contractor shall perform all maintenance work necessary to keep the pavement in a satisfactory condition until the full section is complete and accepted by the Construction Manager. The surface shall be kept clean and free from foreign material. The pavement shall be properly drained at all times. If cleaning is necessary or if the pavement becomes disturbed, any work repairs necessary shall be performed at the Contractor's expense.

METHOD OF MEASUREMENT

101-4.1 PAVEMENT REMOVAL. The unit of measurement for pavement or other surface removal shall be the number of square yards of area removed for each type and depth of pavement surface and base course (stabilized or not) only. Further excavation or embankment will be measured in accordance with P-152.

BASIS OF PAYMENT

101-5.1 PAYMENT. Payment shall be made at contract unit price for the unit of measurement as specified above. This price shall be full compensation for furnishing all materials and for all preparation, hauling, and placing of the material and for all labor, equipment, tools, and incidentals necessary to complete this item.

Payment will be made under:

P-101-1	Remove Bituminous Pavement Section (2-6 inch thick) – per square yard
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P-101-2 Remove Pavement Section (15"-20" PCCP & 6"-8" ATPB/CTB) – per square yard

END OF ITEM P-101

ITEM P-152 EXCAVATION, SUBGRADE AND EMBANKMENT

DESCRIPTION

152-1.1 This item covers excavation, disposal, placement, and compaction of all materials within the limits of the work required to construct safety areas, runways, taxiways, aprons, and intermediate areas as well as other areas for drainage, building construction, parking, or other purposes in accordance with these specifications and in conformity to the dimensions and typical sections shown on the plans.

152-1.2 Classification. All material excavated shall be classified as defined below:

- a. <u>Unclassified Excavation and Embankment.</u> Unclassified excavation shall consist of the excavation and replacement of all material, regardless of its nature, which is not otherwise classified and paid for elsewhere. The material shall be replaced and compacted as shown within the plans. Miscellaneous onsite embankment is considered incidental to this item.
- b. <u>Unclassified Excavation and Export.</u> Unclassified excavation and export shall consist of the excavation and export of all material, regardless of its nature, which is not otherwise classified and paid for elsewhere. The material shall be disposed of at the designated material stockpile area as shown within the plans. Absolutely no material shall be disposed of offsite or be used as fill in other areas without express written consent of the Construction Manager.
- c. <u>Excavation and Embankment of Unsuitable Material.</u> Excavation and embankment of unsuitable material shall consist of the removal and disposal to the designated disposal area of deposits of mixtures of soils or organic matter or highly plastic material considered by the Engineer not suitable for foundation material. Unsuitable materials shall include materials that will decay or produce subsidence in the embankment. This item shall also consist of importing crushed aggregate base material to fill the holes produced by excavation of unsuitable material as directed by the Engineer. If directed by the Engineer, the Contractor will be required to place a non-woven geotextile fabric (Mirafi 160N or equal) prior to placement of imported material. No additional compensation will be made should geotextile fabric be required.
- d. <u>Disposal of Contaminated Material.</u> In the event that potentially hydrocarbon contaminated soils are found during construction, the contractor shall halt all construction activity in the immediate vicinity and notify the Engineer immediately. The contractor shall allow the Engineer 48 hours to sample and perform analytical testing of the potentially hydrocarbon contaminated soils and provide direction for disposal. All material that is deemed to have more than 100 parts per million (ppm) of Total Petroleum Hydrocarbons (TPH) shall be disposed of by the Contractor, at Nevada Thermal Services, Inc. and shall be paid for under "Disposal of Contaminated Material".

Soils <u>that</u> are determined to have less than 100 ppm TPH shall be disposed of in the material disposal area on airport property in locations designated by the engineer. Excavation and disposal of these soils shall be paid for under "Unclassified Excavation".

- e. <u>Disposal Area Grading.</u> As a last step prior to placing topsoil, the material disposal area shall be graded to allow positive drainage of the entire area and of adjacent areas as directed by the Construction Manager. The entire area shall be proof rolled after grading as directed by the Construction Manager prior to placing topsoil.
- f. <u>Subgrade/Subbase Preparation.</u> Subgrade and subbase preparation shall include the scarification and compaction of material under taxiway or runway pavement section as shown within the plans.

CONSTRUCTION METHODS

152-2.1 General. Before beginning excavation, grading, and embankment operations in any area, the area shall be cleared or cleared and grubbed in accordance with Item P-101 or P-151.

The suitability of material to be placed in embankments shall be subject to approval by the Engineer. All unsuitable material shall be disposed of in waste areas as shown on the plans. All waste areas shall be graded to allow positive drainage of the area and adjacent areas. The surface elevation of waste areas shall be specified on the plans or approved by the Engineer.

When the Contractor's excavating operations encounter artifacts of historical or archaeological significance, the operations shall be temporarily discontinued and the Construction Manager notified per Section 70, paragraph 70-20. At the direction of the Construction Manager, the Contractor shall excavate the site in such a manner as to preserve the artifacts encountered and allow for their removal. Such excavation will be paid for as extra work.

Areas outside the limits of the pavement areas where the top layer of soil has become compacted by hauling or other Contractor activities shall be scarified and disked to a depth of 4 inches (100 mm), to loosen and pulverize the soil. Stones or rock fragments larger than 4 inches (100 mm) in their greatest dimension will not be permitted in the top 6 inches (150 mm) of the subgrade.

If it is necessary to interrupt existing surface drainage, sewers or under-drainage, conduits, utilities, or similar underground structures, the Contractor shall be responsible for and shall take all necessary precautions to preserve them or provide temporary services. When such facilities are encountered, the Contractor shall notify the Construction Manager, who shall arrange for their removal if necessary. The Contractor, at their own expense, shall satisfactorily repair or pay the cost of all damage to such facilities or structures that may result from any of the Contractor's operations during the period of the contract.

Blasting shall not be allowed.

152-2.2 Excavation. No excavation shall be started until the work has been staked out by the Contractor and the Construction Manager has obtained from the Contractor, the survey notes of the elevations and measurements of the ground surface. The Contractor and Construction Manager shall agree that the original ground lines shown on the original topographic mapping are accurate, or agree to any adjustments made to the original ground lines.

Digital terrain model (DTM) files of the existing surfaces, finished surfaces and other various surfaces were used to develop the design plans.

Existing grades on the proposed design, where they do not match the locations of actual spot elevations shown on the topographic map, were developed by computer interpolation from those spot elevations. Prior to disturbing original grade, Contractor shall verify the accuracy of the existing ground surface by verifying spot elevations at the same locations where original field survey data was obtained as indicated on the topographic map. Contractor shall recognize that, due to the interpolation process, the actual ground surface at any particular location may differ somewhat from the interpolated surface shown on the design cross sections or obtained from the DTM's. Contractor's verification of original ground surface, however, shall be limited to verification of spot elevations as indicated herein, and no adjustments will be made to the original ground surface unless the Contractor demonstrates that spot elevations shown are incorrect. For this purpose, spot elevations which are within 0.1 foot (30 mm) of the stated elevations for ground surfaces, or within 0.04 foot (12 mm) for hard surfaces (pavements, buildings, foundations, structures, etc.) shall be considered "no change". Only deviations in excess of these will be considered for adjustment of the original ground surface. If Contractor's verification identifies discrepancies in the topographic map, Contractor shall notify the Engineer in writing at least two weeks before disturbance of existing grade to allow sufficient time to verify the submitted information and make adjustments to the proposed design. Disturbance of existing grade in any area shall constitute acceptance by the Contractor of the accuracy of the original elevations shown on the topographic map for that area.

All areas to be excavated shall be stripped of vegetation and topsoil. All suitable excavated material shall be used in the formation of embankment, subgrade, or other purposes as shown on the plans. All unsuitable material shall be disposed of as shown on the plans.

The grade shall be maintained so that the surface is well drained at all times.

When the volume of the excavation exceeds that required to construct the embankments to the grades as indicated on the plans, the excess shall be used to grade the areas of ultimate development or disposed within the material disposal area as directed by the Construction Manager. When the volume of excavation is not sufficient for constructing the embankments to the grades indicated, the deficiency shall be obtained through import.

a. Selective grading. When selective grading is indicated on the plans, the more suitable material designated by the Construction Manager shall be used in constructing the embankment or in capping the pavement subgrade. If, at the time of excavation, it is not possible to place this material in its final location, it shall be stockpiled in approved areas until it can be placed. The more suitable material shall then be placed and compacted as specified. Selective grading shall be considered incidental to the work involved. The cost of stockpiling and placing the material shall be included in the various pay items of work involved.

b. Undercutting. Rock, shale, hardpan, loose rock, boulders, or other material unsatisfactory for safety areas, subgrades, roads, shoulders, or any areas intended for turf shall be excavated to a minimum depth of 12 inches (300 mm) below the subgrade or to the depth specified by the Engineer. Muck, peat, matted roots, or other yielding material, unsatisfactory for subgrade foundation, shall be removed to the depth specified. Unsuitable materials shall be disposed of at designated disposal area. This excavated material shall be paid for at the contract unit price per cubic yard (per cubic meter) for unsuitable material. The excavated area shall be backfilled with suitable material obtained from the grading operations and compacted to specified densities.

c. Over-break. Over-break, including slides, is that portion of any material displaced or loosened beyond the finished work as planned or authorized by the Construction Manager. All over-break shall be graded or removed by the Contractor and disposed of as directed by the Construction Manager. The Construction Manager shall determine if the displacement of such material was unavoidable and their own decision shall be final. Payment will not be made for the removal and disposal of over-break that the Construction Manager determines as avoidable. Unavoidable over-break will be classified as "Unclassified Excavation."

d. Removal of utilities. The removal of existing structures and utilities required to permit the orderly progress of work will be accomplished by the Contractor as indicated on the plans. All existing foundations shall be excavated at least 2 feet (60 cm) below the top of subgrade or as indicated on the plans, and the material disposed of as directed by the Construction Manager. All foundations thus excavated shall be backfilled with suitable material and compacted as specified for embankment or as shown on the plans.

e. Compaction Requirements. The subgrade under areas to be paved shall be compacted to a depth of 8 inches (200 mm) and to a density of not less than 95 percent of the maximum density as determined by ASTM D1557. If subgrade soils encountered are too coarse to test by normal accepted test procedures, the exposed soils may be "proof rolled" to a dense non-yielding surface utilizing a vibratory compactor at the sole discretion of the Engineer. All proof rolling shall be observed and approved by the Engineer.

The in-place field density shall be determined in accordance with ASTM D1556, ASTM D2167 or by observation and proof rolling. The finished grade operations, conforming to the typical cross sections, shall be completed and maintained a suitable distance ahead of the paving operations or as directed by the Engineer.

152-2.3 Borrow Excavation. There are no borrow sources within the boundaries of the airport property. The Contractor shall locate and obtain borrow sources, subject to the approval of the Construction Manager. The Contractor shall notify the Construction Manager at least 14 days prior to beginning the excavation so necessary measurements and tests can be made by the Construction Manager. All borrow pits shall be opened to expose the various strata of acceptable material to allow obtaining a uniform product. Borrow areas shall be drained and left in a neat, presentable condition with all slopes dressed uniformly. Borrow areas shall not create a hazardous wildlife attractant.

152-2.4 Drainage excavation. Not Used

152-2.5 Preparation of cut areas or areas where existing pavement has been removed. In those areas on which a subbase or base course is to be placed, the top 12 inches (300 mm) of subgrade shall be compacted to not less than 95% of maximum density as determined by ASTM 1557.

152-2 Preparation of embankment areas. All sod and vegetative matter shall be removed from the surface upon which the embankment is to be placed. The cleared surface shall be broken up by plowing or scarifying to a minimum depth of 6 inches (150 mm) and shall then be compacted per paragraph 152-2.10.

Sloped surfaces steeper than one (1) vertical to four (4) horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 12 inches (300 mm) and compacted as specified for the adjacent fill.

No direct payment shall be made for the work performed under this section. The necessary clearing and grubbing and the quantity of excavation removed will be paid for under the respective items of work.

152-2.7 Control Strip. The first half-day of construction of subgrade and/or embankment shall be considered as a control strip for the Contractor to demonstrate, in the presence of the Construction Manager, that the materials, equipment, and construction processes meet the requirements of this specification. The sequence and manner of rolling necessary to obtain specified density requirements shall be determined. The maximum compacted thickness may be increased to a maximum of 12 inches (300 mm) upon the Contractor's demonstration that approved equipment and operations will uniformly compact the lift to the specified density. The Construction Manager must witness this demonstration and approve the lift thickness prior to full production.

Control strips that do not meet specification requirements shall be reworked, re-compacted, or removed and replaced at the Contractor's expense. Full operations shall not begin until the control strip has been accepted by the Construction Manager. The Contractor shall use the same equipment, materials, and construction methods for the remainder of construction, unless adjustments made by the Contractor are approved in advance by the Construction Manager.

152-2.8 Formation of Embankments. The material shall be constructed in lifts as established in the control strip, but not less than 6 inches (150 mm) nor more than 12 inches (300 mm) of compacted thickness.

When more than one lift is required to establish the layer thickness shown on the plans, the construction procedure described here shall apply to each lift. No lift shall be covered by subsequent lifts until tests verify that compaction requirements have been met. The Contractor shall rework, re-compact and retest any material placed which does not meet the specifications.

The lifts shall be placed, to produce a soil structure as shown on the typical cross-section or as directed by the Construction Manager. Materials such as brush, hedge, roots, stumps, grass and other organic matter, shall not be incorporated or buried in the embankment.

Earthwork operations shall be suspended at any time when satisfactory results cannot be obtained due to rain, freezing, or other unsatisfactory weather conditions in the field. Frozen material shall not be placed in the embankment nor shall embankment be placed upon frozen material. Material shall not be placed on surfaces that are muddy, frozen, or contain frost. The Contractor shall drag, blade, or slope the embankment to provide surface drainage at all times.

The material in each lift shall be within $\pm 2\%$ of optimum moisture content before rolling to obtain the prescribed compaction. The material shall be moistened or aerated as necessary to achieve a uniform moisture content throughout the lift. Natural drying may be accelerated by blending in dry material or manipulation alone to increase the rate of evaporation.

The Contractor shall make the necessary corrections and adjustments in methods, materials or moisture content to achieve the specified embankment density.

The Construction Manager will take samples of excavated materials which will be used in embankment for testing and develop a Moisture-Density Relations of Soils Report (Proctor) in accordance with ASTM D1557. A new Proctor shall be developed for each soil type based on visual classification.

Density tests will be taken by the Construction Manager for every 3,000 square yards of compacted embankment for each lift which is required to be compacted, or other appropriate frequencies as determined by the Construction Manager.

If the material has greater than 30% retained on the 3/4-inch (19.0 mm) sieve, follow AASHTO T-180 Annex Correction of maximum dry density and optimum moisture for oversized particles.

Rolling operations shall be continued until the embankment is compacted to not less 95% of maximum density as determined by ASTM 1557.

The in-place field density shall be determined in accordance with ASTM D1556 or ASTM D6938 using Procedure A, the direct transmission method. ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated in accordance with ASTM D6938. The Contractor's laboratory shall perform all density tests in the Construction Manager's presence and provide the test results upon completion to the Construction Manager for acceptance. If the specified density is not attained, the area represented by the test or as designated by the Construction Manager shall be reworked and/or re-compacted and additional random tests made. This procedure shall be followed until the specified density is reached.

Compaction areas shall be kept separate, and no lift shall be covered by another lift until the proper density is obtained.

During construction of the embankment, the Contractor shall route all construction equipment evenly over the entire width of the embankment as each lift is placed. Lift placement shall begin in the deepest portion of the embankment fill. As placement progresses, the lifts shall be constructed approximately parallel to the finished pavement grade line.

When rock, concrete pavement, asphalt pavement, and other embankment material are excavated at approximately the same time as the subgrade, the material shall be incorporated into the outer portion of the embankment and the subgrade material shall be incorporated under the future paved areas. Stones, fragmentary rock, and recycled pavement larger than 4 inches (100 mm) in their greatest dimensions will not be allowed in the top 12 inches (300 mm) of the subgrade. Rockfill shall be brought up in lifts as specified or as directed by the Construction Manager and the finer material shall be used to fill the voids forming a dense, compact mass. Rock, cement concrete pavement, asphalt pavement, and other embankment material shall not be disposed of except at places and in the manner designated on the plans or by the Construction Manager.

When the excavated material consists predominantly of rock fragments of such size that the material cannot be placed in lifts of the prescribed thickness without crushing, pulverizing or further breaking down the pieces, such material may be placed in the embankment as directed in lifts not exceeding 2 feet (60 cm) in thickness. Each lift shall be leveled and smoothed with suitable equipment by distribution of spalls and finer fragments of rock. The lift shall not be constructed above an elevation 4 feet (1.2 m) below the finished subgrade.

There will be no separate measurement of payment for compacted embankment. All costs incidental to placing in lifts, compacting, discing, watering, mixing, sloping, and other operations necessary for construction of embankments will be included in the contract price for excavation, borrow, or other items.

152-2.9 Proof rolling. The purpose of proof rolling the subgrade is to identify any weak areas in the subgrade and not for compaction of the subgrade. Before start of embankment and after compaction is completed, the subgrade area shall be proof rolled with a 20 ton (18.1 metric ton) tandem axle dual wheel dump truck loaded to the legal limit with tires inflated to 80/100/150 psi (0.551 MPa/0.689 MPa/1.034 MPa) in the presence of the Construction Manager. Apply a minimum of a single coverage,

or as specified by the Construction Manager, under pavement areas. A coverage is defined as the application of one tire print over the designated area. Soft areas of subgrade that deflect more than 1 inch (25 mm) or show permanent deformation greater than 1 inch (25 mm) shall be removed and replaced with suitable material or reworked to conform to the moisture content and compaction requirements in accordance with these specifications. Construction Manager shall have final authority of any soft areas to be excavated. Removal and replacement of soft areas beyond the lines and grade called for within the plans shall be measured daily prior to backfilling of any holes excavated in the presence of the Construction Manager. Any holes backfilled prior to measurement will not be paid. Payment for work related to soft soils shall be classified as excavation and embankment of unsuitable material.

152-2.10 Compaction Requirements. The subgrade under areas to be paved shall be compacted to a depth of 12 inches (300 mm) and to the density as shown per plan but not less than 95 percent of the maximum dry density as determined by ASTM D1557. The subgrade in areas outside the limits of the pavement areas shall be compacted to a depth of 12 inches (300 mm) and to a density of not less than 90 percent of the maximum density as determined by ASTM D1557.

The material to be compacted shall be within $\pm 2\%$ of optimum moisture content before being rolled to obtain the prescribed compaction (except for expansive soils). When the material has greater than 30 percent retained on the ³/₄ inch (19.0 mm) sieve, follow the methods in ASTM D1557 procedures in AASHTO T180 Annex for correction of maximum dry density and optimum moisture for oversized particles. Tests for moisture content and compaction will be taken at a minimum of 3,000 S.Y. of subgrade. All quality assurance testing shall be done by the Construction Manager.

The in-place field density shall be determined in accordance with ASTM D1556 or ASTM D6938 using Procedure A, the direct transmission method, and ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated in accordance with ASTM D6938 within 12 months prior to its use on this contract. The gage shall be field standardized daily.

Maximum density refers to maximum dry density at optimum moisture content unless otherwise specified.

If the specified density is not attained, the entire lot shall be reworked and/or re-compacted and additional random tests made. This procedure shall be followed until the specified density is reached.

All cut-and-fill slopes shall be uniformly dressed to the slope, cross-section, and alignment shown on the plans or as directed by the Construction Manager and the finished subgrade shall be maintained.

152-2.11 Finishing and protection of subgrade. Finishing and protection of the subgrade is incidental to this item. Grading and compacting of the subgrade shall be performed so that it will drain readily. All low areas, holes or depressions in the subgrade shall be brought to grade. Scarifying, blading, rolling and other methods shall be performed to provide a thoroughly compacted subgrade shaped to the lines and grades shown on the plans. All ruts or rough places that develop in the completed subgrade shall be graded, recompacted, and retested. The Contractor shall protect the subgrade from damage and limit hauling over the finished subgrade to only traffic essential for construction purposes.

The Contractor shall maintain the completed course in satisfactory condition throughout placement of subsequent layers. No subbase, base, or surface course shall be placed on the subgrade until the subgrade has been accepted by the Construction Manager.
152-2.12 Haul. All hauling will be considered a necessary and incidental part of the work. The Contractor shall include the cost in the contract unit price for the pay of items of work involved. No payment will be made separately or directly for hauling on any part of the work.

The Contractor's equipment shall not cause damage to any excavated surface, compacted lift or to the subgrade as a result of hauling operations. Any damage caused as a result of the Contractor's hauling operations shall be repaired at the Contractor's expense.

The Contractor shall be responsible for providing, maintaining and removing any haul roads or routes within or outside of the work area, and shall return the affected areas to their former condition, unless otherwise authorized in writing by the Owner. No separate payment will be made for any work or materials associated with providing, maintaining and removing haul roads or routes.

152-2.13 Surface tolerances. In those areas on which a subbase or base course is to be placed, the surface shall be tested for smoothness and accuracy of grade and crown. Any portion lacking the required smoothness or failing in accuracy of grade or crown shall be scarified to a depth of at least 3 inches (75 mm), reshaped and re-compacted to grade until the required smoothness and accuracy are obtained and approved by the Construction Manager. The Contractor shall perform all final smoothness and grade checks in the presence of the Construction Manager. Any deviation in surface tolerances shall be corrected by the Contractor's expense.

- **a.** Smoothness. The finished surface shall not vary more than +/- ½ inch (12 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with and at right angles to the centerline. The straightedge shall be moved continuously forward at half the length of the 12-foot (3.7-m) straightedge for the full length of each line on a 50-foot (15-m) grid.
- **b.** Grade. The grade and crown shall be measured on a 50-foot (15-m) grid and shall be within +/-0.05 feet (15 mm) of the specified grade.

On safety areas, turfed areas and other designated areas within the grading limits where no subbase or base is to placed, grade shall not vary more than 0.10 feet (30 mm) from specified grade. Any deviation in excess of this amount shall be corrected by loosening, adding or removing materials, and reshaping.

152-2.14 Topsoil. Within the material stockpile area, the stripped material as designated in Item P-151 shall be set to one side and saved until all material placement has taken place for the project. After all grading and compaction has been completed within the material stockpile area, the stripped material shall be bladed over the material placement area in a uniform depth.

No direct payment will be made for topsoil placement.

152-2.11 Disposal area grading. After completion of material placement and prior to placement of topsoil within the disposal area, the entire area shall be graded to provide positive drainage as directed by the Engineer.

152-2.12 Dewatering. Construction dewatering may be required to prevent unstable trench wall conditions and to provide a firm, unyielding subgrade for construction. Groundwater shall be lowered below the bottom of excavation to sufficient depth to provide a firm bearing surface. Groundwater shall be lowered prior to excavation.

The dewatering system should be a Contractor designed system. Control of groundwater should be accomplished in such a manner that will preserve the strength of the foundation soils, will not cause instability of excavated slopes, and will not result in damage to existing structures or building foundations.

Open pumping will not be permitted if it results in boils, flowing sands, loss of fines, or settlement of existing structures. Water should not be allowed to pool and remain in the excavated area over an extended period of time.

The Contractor is cautioned that existing groundwater may be contaminated with petroleum products or other materials. Water must be pretreated for sediments and/or contaminates prior to discharge. The construction method for handling deep localized excavations should consider keeping pumped water to an absolute minimum.

Dewatering methods must be approved by the Engineer and Construction Manager.

152-2.13 Remove, stockpile, and reset existing surface rock. The Contractor shall move the existing surface rock as needed for the work shown on the drawings, including but not limited to earthwork, paving, trenching, and electrical sign installation. The Contractor may stockpile the material onsite, as allowed by airport operations, however stockpiling within an active Taxiway or Runway safety area will not be permitted. All active safety and object free areas must meet grading requirements.

Contractor shall restore the surface rock at the conclusion of construction activities in a given area. Place material at the thickness, grade, and to the areas as shown on the plans. Contractor shall take necessary precautions to prevent dirt, mud, or construction debris being mixed within the surface rock material. Surface rock must be clean from mud, dirt, or construction debris to the satisfaction of the Construction Manager. After placing, roll disturbed surface rock material with a steel wheeled roller of sufficient weight to seat the material. Final surface rock shall be placed such that it is free from ruts, wheel marks, and localized mounding.

METHOD OF MEASUREMENT

152-3.1 Excavation and replacement of unsuitable material shall be paid for on the basis of the number of in-place cubic yards (meters). Measurement for unsuitable material excavation and embankment shall be performed on a daily basis in the presence of the Construction Manager and the Contractor prior to backfilling. No backfilling will be permitted without prior documentation of volume of excavated and embankment material to be placed.

152-3.2 For payment specified by the cubic yard (cubic meter), measurement for all excavation and embankment shall be computed by the average end area method. The end area is that bound by the original ground line established by field cross sections and the final theoretical pay line established by excavation and embankment cross sections shown on the plans, subject to verification by the Construction Manager. After completion of all excavation and embankment operations and prior to the placing of base or subbase material, the final excavation and embankment shall be verified by the Construction Manager by means of field cross sections taken randomly at intervals not exceeding 100 linear feet (30 meters).

Final field cross sections shall be employed if the following changes have been made:

- **a.** Plan width of embankments or excavations are changed by more than plus or minus 1.0 foot (0.3 meter); or
- **b.** Plan elevations of embankments or excavations are changed by more than plus or minus 0.5 foot (0.15 meter).

152-3.4 Subgrade/subbase preparation will be measured by the square yard (square meter) as indicated in the Owner's estimate. The area to be paid for will be calculated on the basis of the dimensions shown on the contract drawings or as adjusted by the amount of any change ordered by the Owner. No allowance will be made for material outside said dimensions unless ordered by the Owner.

BASIS OF PAYMENT

152-4.1 For "Excavation and Export" payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation including Contractor overhead and profit for furnishing all materials, labor, equipment, tools, hauling, disposal site preparation and restoration, and incidentals necessary to complete the item.

152-4.2 For "Excavation and Embankment" payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation including Contractor overhead and profit for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.

152-4.3 For "Excavation and Embankment of Unsuitable Material" payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation including Contractor overhead and profit for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.

152.4.4 For "Subgrade/Subbase Preparation" payment shall be made at the contract unit price per square yard (square meter). This price shall be full compensation including Contractor overhead and profit for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.

152-4.5 For "Disposal of Contaminated Material" payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation including Contractor overhead and profit for furnishing all materials, labor, equipment, tools, disposal, and incidentals necessary to complete the item.

152-4.6. There will be no direct payment for dewatering. Payment for dewatering will be considered incidental to applicable items of work.

Payment will be made under:

Item P-152-1	Unclassified Excavation and Export – per cubic yard (cubic meter)
Item P-152-2	Unclassified Excavation and Embankment- per cubic yard (cubic meter)
Item P-152-3	Excavation and Embankment of Unsuitable Material (Contingent) – per cubic yard (cubic meter)
Item P-152-4	Subgrade/Subbase Preparation - per square yard (square meter)
Item P-152-5	Disposal of Contaminated Material (Contingent) - per cubic yard (cubic meter)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

American Association of State Highway and Transportation Officials (AASHTO)

AASHTO T-180	Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
ASTM International (ASTM)	
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft ³ (600 kN-m/m ³))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³ (2700 kN-m/m ³))
ASTM D6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
Advisory Circulars (AC)	
AC 150/5370-2	Operational Safety on Airports During Construction Software
Software	

FAARFIELD – FAA Rigid and Flexible Iterative Elastic Layered Design

U.S. Department of Transportation

FAA RD-76-66 Design and Construction of Airport Pavements on Expansive Soils

END OF ITEM P-152

ITEM P-153 CONTROLLED LOW-STRENGTH MATERIAL (CLSM)

DESCRIPTION

153-1.1 This item shall consist of furnishing, transporting, and placing a controlled low-strength material (CLSM) as flowable backfill in trenches or at other locations shown on the plans or as directed by the Construction Manager

MATERIALS

153-2.1 Materials.

a. Cement. Cement shall conform to the requirements of ASTM C150 Type II.

b. Fly ash. Fly ash shall conform to ASTM C618, Class C or F.

c. Fine aggregate (sand). Fine aggregate shall conform to the requirements of ASTM C33 except for aggregate gradation. Any aggregate gradation which produces the specified performance characteristics of the CLSM and meets the following requirements, will be accepted.

Sieve Size	Percent Passing by weight
3/4 inch (19.0 mm)	100
No. 200 (75 µm)	0 - 12

d. Water. Water used in mixing or curing shall be from potable water sources. Other sources shall be tested in accordance with ASTM C1602 prior to use.

MIX DESIGN

153-3.1 Proportions. The Contractor shall submit, to the CONSTRUCTION MANAGER, a mix design including the proportions and source of aggregate, fly ash, cement, water, and approved admixtures. No CLSM mixture shall be produced for payment until the CONSTRUCTION MANAGER has given written approval of the proportions. The proportions shall be prepared by a laboratory and shall remain in effect for the duration of the project. The proportions shall establish a single percentage or weight for aggregate, fly ash, cement, water, and any admixtures proposed. Laboratory costs are incidental to this item.

a. Compressive strength. CLSM shall be designed to achieve a 28-day compressive strength of 100 to 200 psi (690 to 1379 kPa) when tested in accordance with ASTM D4832, with no significant strength gain after 28 days.

b. Consistency. Design CLSM to achieve a consistency that will produce an approximate 8-inch (200 mm) diameter circular-type spread without segregation. CLSM consistency shall be determined per ASTM D6103.

CONSTRUCTION METHODS

153-4.1 Placement.

a. Placement. CLSM may be placed by any reasonable means from the mixing unit into the space to be filled. Agitation is required during transportation and waiting time. Placement shall be performed so structures or pipes are not displaced from their final position and intrusion of CLSM into unwanted areas is avoided. The material shall be brought up uniformly to the fill line shown on the plans or as directed by the Construction Manager. Each placement of CLSM shall be as continuous an operation as possible. If CLSM is placed in more than one lift, the base lift shall be free of surface water and loose foreign material prior to placement of the next lift.

b. Contractor Quality Control. The Contractor shall collect all batch tickets to verify the CLSM delivered to the project conforms to the mix design. The Contractor shall verify daily that the CLSM is consistent with 153-3.1a and 153-3.1b. Adjustments shall be made as necessary to the proportions and materials as needed. The Contractor shall provide all batch tickets to the Construction Manager.

c. Limitations of placement. CLSM shall not be placed on frozen ground. Mixing and placing may begin when the air or ground temperature is at least $35^{\circ}F(2^{\circ}C)$ and rising. Mixing and placement shall stop when the air temperature is $40^{\circ}F(4^{\circ}C)$ and falling or when the anticipated air or ground temperature will be $35^{\circ}F(2^{\circ}C)$ or less in the 24-hour period following proposed placement. At the time of placement, CLSM shall have a temperature of at least $40^{\circ}F(4^{\circ}C)$.

153-4.2 Curing and protection.

a. Curing. The air in contact with the CLSM shall be maintained at temperatures above freezing for a minimum of 72 hours. If the CLSM is subjected to temperatures below $32^{\circ}F$ (0°C), the material may be rejected by the Construction Manager if damage to the material is observed.

b. Protection. The CLSM shall not be subject to loads and shall remain undisturbed by construction activities for a period of 48 hours or until a compressive strength of 15 psi (105 kPa) is obtained. The Contractor shall be responsible for providing evidence to the Construction Manager that the material has reached the desired strength. Acceptable evidence shall be based upon compressive tests made in accordance with paragraph 153-3.1a.

153-4.3 Quality assurance (QA) acceptance. CLSM QA acceptance shall be based upon batch tickets provided by the Contractor to the Construction Manager to confirm that the delivered material conforms to the mix design. The Contractor shall verify by additional testing, each 1,000 cubic yards (765 m³) of material used. Verification shall include confirmation of material proportions and tests of compressive strength to confirm that the material meets the original mix design and the requirements of CLSM as defined in this specification. Adjustments shall be made as necessary to the proportions and materials prior to further production.

METHOD OF MEASUREMENT

153-5.1 Measurement.

No separate measurement for payment shall be made for controlled low strength material (CLSM). CLSM shall be considered necessary and incidental to the work of this Contract.

BASIS OF PAYMENT

153-6.1 Payment.

No payment will be made separately or directly for controlled low strength material (CLSM). CLSM shall be considered necessary and incidental to the work of this Contract.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM C150Standard Specification for Portland CementASTM C618Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in ConcreteASTM C595Standard Specification for Blended Hydraulic CementsASTM C1602Standard Specification for Mixing Water Used in the Production of Hydraulic Cement ConcreteASTM D4832Standard Test Method for Preparation and Testing of Controlled Low- Strength Material (CLSM) Test CylindersASTM D6103Flow Consistency of Controlled Low Strength Material (CLSM)	ASTM C33	Standard Specification for Concrete Aggregates
ASTM C618Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in ConcreteASTM C595Standard Specification for Blended Hydraulic CementsASTM C1602Standard Specification for Mixing Water Used in the Production of Hydraulic Cement ConcreteASTM D4832Standard Test Method for Preparation and Testing of Controlled Low- Strength Material (CLSM) Test CylindersASTM D6103Flow Consistency of Controlled Low Strength Material (CLSM)	ASTM C150	Standard Specification for Portland Cement
ASTM C595Standard Specification for Blended Hydraulic CementsASTM C1602Standard Specification for Mixing Water Used in the Production of Hydraulic Cement ConcreteASTM D4832Standard Test Method for Preparation and Testing of Controlled Low- Strength Material (CLSM) Test CylindersASTM D6103Flow Consistency of Controlled Low Strength Material (CLSM)	ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C1602Standard Specification for Mixing Water Used in the Production of Hydraulic Cement ConcreteASTM D4832Standard Test Method for Preparation and Testing of Controlled Low- Strength Material (CLSM) Test CylindersASTM D6103Flow Consistency of Controlled Low Strength Material (CLSM)	ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM D4832Standard Test Method for Preparation and Testing of Controlled Low- Strength Material (CLSM) Test CylindersASTM D6103Flow Consistency of Controlled Low Strength Material (CLSM)	ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D6103 Flow Consistency of Controlled Low Strength Material (CLSM)	ASTM D4832	Standard Test Method for Preparation and Testing of Controlled Low- Strength Material (CLSM) Test Cylinders
	ASTM D6103	Flow Consistency of Controlled Low Strength Material (CLSM)

END OF ITEM P-153

ITEM P-201S ASPHALT TREATED PERMEABLE BASE (ATPB) COURSE

(Central Plant Hot Mix)

DESCRIPTION

201S-1.1 This item shall consist of a permeable base course composed of mineral aggregate, hydrated lime, and bituminous material, mixed in a central mixing plant and placed on a prepared course in accordance with these Specifications and in conformity with the lines, grades, thicknesses, and typical cross sections shown on the Plans.

The base course shall be constructed as shown on the Plans in lifts not to exceed three inches (3") in thickness. The three inch (3") maximum lift thickness may be waived if the Contractor is able to demonstrate by means of a test section, that compaction, texture, and surface tolerance can be obtained for a thicker lift. If the results of the test are satisfactory, the Construction Manager may authorize the course material be placed in lifts no greater than four and one-half inches (4.5") in compacted thickness. The thickness of each lift must be within 0.05 foot of the designated elevation of that lift.

The Standard "Reference Specifications" as used in these Specifications for the ATPB refer to the "Standard Specifications", State of California, Department of Transportation current edition. The ATPB shall conform to Section 29 of the "Reference Specifications" except as modified by these Specifications.

MATERIALS

The materials for the ATPB shall conform to the following:

201S-2.1 Aggregate. Aggregates shall be clean and free from decomposed material, organic materials, and other deleterious substances.

Aggregate shall conform to the following grading:

SIEVE DESIGNATION	PERCENT PASSING BY DRY WEIGHT
1"	100
3/4"	90-100
1/2"	35-65
3/8"	20-45
No. 4	0-10
No. 8	0-5
No. 200	0-2

Aggregate shall conform to the quality requirements in Table 1 prior to the addition of asphalt.

TEST	REQUIREMENT
Percentage of Crush Particles	00% Min
Caltrans Test 205	9070 WIIII.
Los Angeles Rattler Loss at 500Rev.	450/ May
Caltrans Test 211	4370 Wlax.
Cleanness Value	570/ Min
Caltrans Test 227	3/% Min.
Film Stripping	250/ May
Caltrans Test 302	2370 Max.

TABLE 1. AGGREGATE QUALITY

201S-2.2 Hydrated Lime. Hydrate lime shall conform to the quality requirements of ASTM C1097.

201S-2.3 Bituminous material. Bituminous material shall conform to the quality requirements for Viscosity Grade AC-20 or Performance Grade PG 64-22 Bitumen conforming to ASTM D3381.

The Contractor shall furnish vendor's certified test reports for each truck and/or tank load of hydrated lime and bitumen shipped for use on the Project. The report shall be delivered to the Engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the lime and/or bituminous material shall be the basis for Final Acceptance.

COMPOSITION

201S-3.1 Composition of mixture. The bituminous mix shall be composed of a mixture of aggregate, lime and bituminous material. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that the resulting mixture meets the grading requirements of the Job Mix Formula.

201S-3.2 Job mix formula. No bituminous mixture for pavement shall be produced until a Job Mix Formula has been approved by the Owner. The Formula shall be submitted in writing by the Contractor to the Owner at least fourteen (14) days prior to the start of paving operations and shall indicate the definite percentage of each sieve fraction of aggregate, the percentage of bitumen and the temperature of the completed mixture when discharged from the mixer. All aggregate test data and mixture test properties used to develop the Job Mix Formula shall also be submitted. The Job Mix Formula for each mixture shall be in effect until modified in writing by the Owner. Should a change in source of materials be made, a new Job Mix Formula must be established before the new material is used.

The bituminous mixture shall be designed using procedures contained in Chapter V, Marshall Method of Mix Design, of the Asphalt Institutes Manual Series No. 2 (MS-2), current edition, and as modified by these Specifications. A minimum of three (3) individual test specimens (total of twelve (12) specimens) mixed with 2.0, 2.5, 3.0 and 3.5 percent bitumen by weight of total mixture shall be compacted using fifty (50) blows each side with a Marshall hammer. The test specimens shall be compacted at $250 \pm 5^{\circ}$ F. Prior to the addition of bitumen, the aggregate blend shall be mixed with one- and one-half percent (1-1/2%) hydrated lime. The lime shall be uniformly mixed after adjusting the aggregate moisture to four percent (4%). The aggregate/lime mixture shall then be dried back prior to the addition of bitumen. The mixture shall be tested in accordance with the items in Table 2.

TEST	Method	
Unit Weight	ASTM D 1188	
Theoretical Maximum Specific Gravity	ASTM D 2041	
Indirect Tension Test	ASTM D 6931	
Effect of Water on Bituminous Paving Mixtures (Texas Boiling Test)	Tex 530-C	

TABLE 2. MIX DESIGN TESTS

The unit weight and specific gravity test data shall be used to determine the percentage of air voids in the compacted specimen. Design of the ATPB should provide for air voids of 20 ± 5 percent.

<u>Approval of Job-Mix Formula.</u> The aggregate-bitumen mixture shall meet the following requirements when tested using procedures contained in Chapter V, Marshall Method of Mix Design, of the Asphalt Institute's Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete, current edition.

- (1) The stability at 140° F shall not be less than 500 pounds (50 blows of Marshall Hammer)
- (2) The flow shall not be less than 6 nor more than 16.
- (3) The percentage of aggregate voids filled with bitumen (VFA) shall have a maximum value of 30.
- (4) The coefficient of permeability of laboratory compacted specimens shall exceed 5,000 feet per day. (1.75 cm/sec).

<u>Uniformity</u>. The asphalt treated permeable base shall not be started until the Contractor has submitted and received approval of the job-mix formula.

The job mix tolerances shown on Table 3 shall be applied to the Job Mix Formula to establish a job control grading band. The full tolerances still will apply if application of the job mix tolerances results in a job control grading band outside the master grading band.

(Dased on a Single Test)		
MATERIAL	TOLERANCE	
Aggregate Passing No. 4 Sieve or Larger	$\pm 5\%$	
Aggregate Passing No. 8 and No. 16 Sieves	±3%t	
Aggregate Passing No. 200 Sieve	$\pm 1\%$	
Bitumen	$\pm 0.5\%$	
Temperature of Mixture	±20° F	

TABLE 3. JOB MIX FORMULA TOLERANCES (Based on a Single Test)

201S-3.3 Test Section. Prior to full production, the Contractor shall prepare a quantity of bituminous mixture according to the Job Mix Formula. The amount of mixture should sufficient to construct a test section one hundred feet (100') long and twelve feet (12') wide, placed in two (2) sections, and shall be of the same depth specified for the construction of the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section.

The test section shall be allowed to cool to ambient temperatures. The cooled section shall be proof-rolled with loaded 20-ton dump truck, so that the middle 1/3 of the section receives a minimum of four (4)

complete passes. The test section shall also be tested for permeability. A water truck shall flood a portion of the test section selected by the Engineer for a period of five (5) minutes.

Ruts or depressions greater than 1/2-inch in depth when measured with a 16-foot straightedge or ponded water visible from the surface of the slab one (1) minute after the application of the water shall constitute an unsatisfactory test section.

If the test section should prove to be unsatisfactory, the necessary adjustments to the mix design, plant operation and/or rolling procedures shall be made. Additional test sections, as required, shall be constructed and evaluated for conformance to the Specifications. When test sections do not conform to Specification Requirements, the pavement shall be removed and replaced at the Contractor's expense. A marginal quality test section that has been placed may be left in place. If a second test section also does not meet Specification Requirements, both sections shall be removed at the Contractor's expense. Full production shall not begin without the Engineer's approval. Test sections which are acceptable when left in place, will be paid for in accordance with Paragraph 6.1.

CONSTRUCTION METHODS

201S-4.1 Storing, proportioning, and mixing. Aggregates and asphalt for ATPB shall be stored, proportioned and mixed in the same manner provided for storing, proportioning, and mixing aggregates and asphalt for asphalt concrete in Section 39-3.01 of the "Reference Specifications" except as follows:

- **a.** The aggregate need not be separated into sizes.
- **b.** The temperature of the aggregate before adding of the asphalt binder shall be no less than 275° F nor more than 325° F.
- **c.** ATPB stored in excess of two (2) hours shall not be used in the Work.
- **d.** For initial construction, the aggregate and lime mixture shall be combined with two and one-half (2-1/2) percent paving asphalt by weight of total mixture. After testing samples of the Contractor's proposed aggregate supply, the Engineer may order an increase or decrease in the asphalt content. If such increase or decrease is ordered, and the increase or decrease exceeds the specified amount by more than 0.5 percent by weight of total mixture, the compensation payable to the Contractor for the ATPB will be increased or decreased on the basis of the total increase or decrease in asphalt in the same manner as provided for any increase or decrease in asphalt concrete in Section 39-3.03 of the "Reference Specifications".
- e. The asphalt content of the asphalt mixture will be determined, by daily tank measurements and for aggregate gradation in accordance with ASTM C 117 and C 136. The bitumen ratio (by weight of mixture) shall not vary more than 0.50 percent from the approved bitumen content.

201S-4.2 Spreading and compacting ATPB. ATPB shall be spread and compacted in the same manner as provided for asphalt concrete in these Specifications.

- **a.** ATPB shall be spread only when the atmospheric temperature is above 40° F.
- **b.** ATPB shall be spread and compacted in one (1) layer. A layer refers to a maximum compacted thickness of three (3) to four and one-half (4.5) inches.

c. ATPB shall be compacted in accordance with the following sequence methods:

(1) INITIAL BREAKDOWN COMPACTION

One (1) complete coverage with a steel-tired, 2-axle tandem roller which will produce an operating weight of not more than 110 pounds per linear inch of steel tire width. Compaction shall begin when the temperature of the base mixture is less than 250° F and shall be completed before the base mixture is less than 200° F. ATPB shall not be cooled with water.

(2) FINAL COMPACTION

One (1) complete cover with a steel-tired, 2-axle tandem roller weighing not less than eight (8) tons nor more than twelve (12) tons. Compaction shall begin when the temperature of the base mixture is less than 150° F and shall be completed before the base mixture is less than 100° F. ATPB shall not be cooled with water.

- **d.** Vibratory rollers meeting the above requirements may be used provided the vibratory unit is turned off.
- e. The finished surface of each ATPB lift shall be uniform and shall not vary at any point more than 0.05 foot above or below the grade established by the Engineer, but final surface of ATPB shall be within -0.05 foot and +0.00 foot.
- **f.** Care shall be exercised to prevent contamination of ATPB. ATPB which in the opinion of the Engineer, has been contaminated, shall be removed and replaced by the Contractor at this expense.
- **g.** The finished ATPB surface shall be cured fully prior to placing Portland Cement Concrete (PCC) pavement. As a minimum, the ATPB shall be cured at least seventy-two (72) hours prior to PCC paving.
- **h.** Compaction adjacent to existing PCC pavement may require the use of hand tampers.
- i. The finished ATPB surface shall be whitewashed with a limewater solution containing 15% hydrated lime by weight of water prior to form placement. The limewater solution shall be applied at a rate of 225 square feet per gallon.

Damage to the ATPB shall be repaired promptly by the Contractor at his expense, as directed by the Engineer.

201S-4.3 Surfaces not within tolerance. ATPB with a surface higher than 0.05 foot above the grade established by the Engineer shall be removed and replaced with ATPB which complies with these Specifications, or if permitted by the Engineer, the high spots may be removed to within specified tolerance by any method that does not produce contaminating fines or damage the base to remain in place. Grinding will not be permitted. The final ATPB surface shall be within -0.05 feet and +0.00 feet.

Hardened ATPB with a surface lower than 0.05 foot below the grade established by the Engineer shall be removed and replaced with ATPB which complies with these Specifications, or if permitted by the Engineer, the low areas shall be filled with pavement materials as follows:

- **a.** When pavement material is Portland Cement Concrete, the low areas shall be filled with pavement concrete at the time and in the same operation in which the pavement is placed.
- **b.** Full compensation for filling low areas will be considered as included in the contract price paid for ATPB and no additional compensation will be allowed therefore.

METHOD OF MEASUREMENT

201S-5.1 Measurement. The quantity of ATPB to be paid for will be measured by the square yard for the ATPB indicated in the Owner's estimate. The area to be paid for will be calculated on the basis of the dimensions shown of the Plans adjusted by the amount of any change ordered by the Owner. No allowance will be made for ATPB placed outside said dimensions unless otherwise ordered by the Owner.

BASIS OF PAYMENT

201S-6.1 Payment. The Contract Price paid per square yard for ATPB of the type indicated in the Owner's estimate shall include full compensation including Contractor overhead and profit for furnishing all labor materials, paving asphalt, tools, equipment and incidentals, and for doing all the work involved in constructing ATPB, complete in place, as shown on the Plans, as specified in these Specifications and the Special Provision and as directed by the Owner.

Payment will be made under:

Item P-201S-1 Asphalt Treated Permeable Base Course (6 inch thick) – per square yard

TESTING REQUIREMENTS

ASTM C 117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	Standard Test Method for Resistance to Degradation of Small-Size
ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D 1188	Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples
ASTM D 2041	Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 6931	Standard Test Method for Indirect (IDT) Strength of Bituminous Mixtures
Caltrans Test 205	Method for Determining Percentage of Crushed Particles
Caltrans Test 302	Method of Test for Film Stripping
Tex 530-C	Effect of Water on Bituminous Paving Mixtures
	MATERIAL REQUIREMENTS
ASTM C 1097	Standard Specification for Hydrated Lime for Use in Asphalt Cement or Bituminous Pavements
ASTM D 3381	Standard Specification for Viscosity Graded Asphalt Cement for Use in Pavement Construction

END OF P-201S

ITEM P-209 CRUSHED AGGREGATE BASE COURSE

DESCRIPTION

209-1.1 This item consists of a base course composed of crushed aggregate base constructed on a prepared course in accordance with these specifications and in conformity to the dimensions and typical cross-sections shown on the plans.

MATERIALS

209-2.1 Crushed aggregate base. Crushed aggregate shall consist of clean, sound, durable particles of crushed stone, crushed gravel and shall be free from coatings of clay, silt, organic material, clay lumps or balls or other deleterious materials or coatings. The method used to produce the crushed gravel shall result in the fractured particles in the finished product as consistent and uniform as practicable. Fine aggregate portion, defined as the portion passing the No. 4 (4.75 mm) sieve shall consist of fines from the coarse aggregate requirements for wear and soundness. Aggregate base material requirements are listed in the following table.

Material Test	Requirement	Standard	
	Coarse Aggregate		
Resistance to Degradation	Loss: 45% maximum	ASTM C131	
Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate	Lossafter5cycles:12%maximum usingSodium sulfate- or -18%maximum using magnesium sulfate	ASTM C88	
Percentage of Fractured Particles	Minimum 90% by weight of particles with at least two fractured faces and 100% with at least one fractured face ¹	ASTM D5821	
Flat Particles, Elongated Particles, or Flat and Elongated Particles	10% maximum, by weight, of flat, elongated, or flat and elongated particles 2	ASTM D4791	
Clay lumps and friable particles	Less than or equal to 3 percent	ASTM C142	
Fine Aggregate			
Liquid limit	Less than or equal to 25	ASTM D4318	
Plasticity Index	Not more than five (5)	ASTM D4318	

CRUSHED AGGREGATE BASE MATERIAL REQUIREMENTS

¹ The area of each face shall be equal to at least 75% of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces.

² A flat particle is one having a ratio of width to thickness greater than five (5); an elongated particle is one having a ratio of length to width greater than five (5).

209-2.2 Gradation Requirements. The gradation of the aggregate base material shall meet the requirements of the gradation given in the following table when tested per ASTM C117 and ASTM C136. The gradation shall be well graded from coarse to fine and shall not vary from the lower limit on one sieve to the high limit on an adjacent sieve or vice versa.

Sieve Size	Design Range Percentage b Weight passing	by	Contractor's Final Gradation	Job Control Grading Band Tolerances ¹ (Percent)
2 inch (50 mm)	100			0
1-1/2 inch (37.5 mm)	95-100			± 5
1 inch (25.0 mm)	70-95			± 8
3/4 inch (19.0 mm)	55-85			± 8
No. 4 (4.75 mm)	30-60			± 8
No. 40 ² (425 μm)	10-30			± 5
No. 200 ² (75 μm)	0-5			± 3

Gradation of Aggregate Base

¹ The "Job Control Grading Band Tolerances for Contractor's Final Gradation" in the table shall be applied to "Contractor's Final Gradation" to establish a job control grading band. The full tolerance still applies if application of the tolerances results in a job control grading band outside the design range.

 2 The fraction of material passing the No 200 (75 $\mu m)$ sieve shall not exceed two-thirds the fraction passing the No 40 (425 $\mu m)$ sieve.

209-2.3 Sampling and testing.

a. Aggregate base materials. The Contractor shall take samples of the aggregate base in accordance with ASTM D75 to verify initial aggregate base requirements and gradation. Material shall meet the requirements in paragraph 209-2.1. This sampling and testing will be the basis for approval of the aggregate base quality requirements.

b. Gradation requirements. The Contractor shall take at least two aggregate base samples per day in the presence of the Construction Manager to check the final gradation. Sampling shall be per ASTM D75. Material shall meet the requirements in paragraph 209-2.2. The samples shall be taken from the in-place, un-compacted material at sampling points and intervals designated by the Construction Manager.

209-2.4 Separation geotextile. Not used.

CONSTRUCTION METHODS

209-3.1 Control strip. The first half-day of construction shall be considered the control strip. The Contractor shall demonstrate, in the presence of the Construction Manager, that the materials, equipment, and construction processes meet the requirements of the specification. The sequence and manner of rolling necessary to obtain specified density requirements shall be determined. The maximum compacted thickness may be increased to a maximum of 12 inches (300 mm) upon the Contractor's demonstration that approved equipment and operations will uniformly compact the lift to the specified density. The Construction Manager must witness this demonstration and approve the lift thickness prior to full production.

Control strips that do not meet specification requirements shall be reworked, re-compacted or removed and replaced at the Contractor's expense. Full operations shall not continue until the control strip has been accepted by the Construction Manager. The Contractor shall use the same equipment, materials, and construction methods for the remainder of construction, unless adjustments made by the Contractor are approved by the Construction Manager.

209-3.2 Preparing underlying subgrade and/or subbase. The underlying subgrade and/or subbase shall be checked and accepted by the Construction Manager before base course placing and spreading operations begin. Re-proof rolling of the subgrade or proof rolling of the subbase in accordance with Item P-152, at the Contractor's expense, may be required by the Construction Manager if the Contractor fails to ensure proper drainage or protect the subgrade and/or subbase. Any ruts or soft, yielding areas due to improper drainage conditions, hauling, or any other cause, shall be corrected before the base course is placed. To ensure proper drainage, the spreading of the base shall begin along the centerline of the pavement on a crowned section or on the high side of the pavement with a one-way slope.

209-3.3 Production. The aggregate shall be uniformly blended and, when at a satisfactory moisture content per paragraph 209-3.5, the approved material may be transported directly to the placement.

209-3.4 Placement. The aggregate shall be placed and spread on the prepared underlying layer by spreader boxes or other devices as approved by the Construction Manager, to a uniform thickness and width. The equipment shall have positive thickness controls to minimize the need for additional manipulation of the material. Dumping from vehicles that require re-handling shall not be permitted. Hauling over the uncompacted base course shall not be permitted.

The aggregate shall meet gradation and moisture requirements prior to compaction. The base course shall be constructed in lifts as established in the control strip, but not less than 4 inches (100 mm) nor more than 12 inches (300 mm) of compacted thickness.

When more than one lift is required to establish the layer thickness shown on the plans, the construction procedure described here shall apply to each lift. No lift shall be covered by subsequent lifts until tests verify that compaction requirements have been met. The Contractor shall rework, re-compact and retest any material placed which does not meet the specifications at the Contractor's expense.

209-3.5 Compaction. Immediately after completion of the spreading operations, compact each layer of the base course, as specified, with approved compaction equipment. The number, type, and weight of rollers shall be sufficient to compact the material to the required density within the same day that the aggregate is placed on the subgrade.

The field density of each compacted lift of material shall be at least 100% of the maximum density of laboratory specimens prepared from samples of the subbase material delivered to the jobsite. The laboratory specimens shall be compacted and tested in accordance with ASTM D1557. The moisture content of the material during placing operations shall be within ± 2 percentage points of the optimum moisture content as determined by ASTM D1557. Maximum density refers to maximum dry density at optimum moisture content unless otherwise specified.

209-3.6 Weather limitations. Material shall not be placed unless the ambient air temperature is at least 40° F (4°C) and rising. Work on base course shall not be conducted when the subgrade or subbase is wet or frozen or the base material contains frozen material.

209-3.7 Maintenance. The base course shall be maintained in a condition that will meet all specification requirements. When material has been exposed to excessive rain, snow, or freeze-thaw conditions, prior to placement of additional material, the Contractor shall verify that materials still meet all specification requirements. Equipment may be routed over completed sections of base course, provided that no damage results and the equipment is routed over the full width of the completed base course. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the Contractor at the Contractor's expense.

209-3.8 Surface tolerances. After the course has been compacted, the surface shall be tested for smoothness and accuracy of grade and crown. Any portion lacking the required smoothness or failing in accuracy of grade or crown shall be scarified to a depth of at least 3 inches (75 mm), reshaped and recompacted to grade until the required smoothness and accuracy are obtained and approved by the Construction Manager. Any deviation in surface tolerances shall be corrected by the Contractor at the Contractor's expense. The smoothness and accuracy requirements specified here apply only to the top layer when base course is constructed in more than one layer.

a. Smoothness. The finished surface shall not vary more than 3/8-inch (9 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with and at right angles to the centerline. The straightedge shall be moved continuously forward at half the length of the 12-foot (3.7-m) straightedge for the full length of each line on a 50-foot (15-m) grid.

b. Grade. The grade and crown shall be measured on a 50-foot (15-m) grid and shall be within +0 and -1/2 inch (12 mm) of the specified grade.

209-3.9 Acceptance sampling and testing. Crushed aggregate base course shall be accepted for density and thickness on an area basis. Two tests shall be made for density and thickness for each 1200 square yds (1000 m2). Sampling locations will be determined on a random basis per ASTM D3665.

a. Density. The Contractor's laboratory shall perform all density tests in the Construction Manager's presence and provide the test results upon completion to the Construction Manager for acceptance.

Each area shall be accepted for density when the field density is at least 100% of the maximum density of laboratory specimens compacted and tested per ASTM D1557. The in-place field density shall be determined per ASTM D1556 or ASTM D6938 using Procedure A, the direct transmission method, and ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated in accordance with ASTM D6938. If the specified density is not attained, the area represented by the failed test must be reworked and/or recompacted and two additional random tests made. This procedure shall be followed until the specified density is reached. Maximum density refers to maximum dry density at optimum moisture content unless otherwise specified.

b. Thickness. Depth tests shall be made by test holes at least 3 inches (75 mm) in diameter that extend through the base. The thickness of the base course shall be within +0 and -1/2 inch (12 mm) of the specified thickness as determined by depth tests taken by the Contractor in the presence of the CONSTRUCTION MANAGER for each area. Where the thickness is deficient by more than 1/2-inch (12 mm), the Contractor shall correct such areas at no additional cost by scarifying to a depth of at least 3 inches (75 mm), adding new material of proper gradation, and the material shall be blended and recompacted to grade. The Contractor shall replace, at his expense, base material where depth tests have been taken.

METHOD OF MEASUREMENT

209-4.1 The quantity of crushed aggregate base course (6-inch thick) will be determined by measurement of the number of square yards (square meters)of material actually constructed and accepted by the Construction Manager as complying with the plans and specifications. Base materials shall not be included in any other excavation quantities.

209-4.2. The quantity of crushed aggregate base leveling course shall be measured by the ton, or fraction, of material placed and accepted by the Construction Manager. Contractor must coordinate with the Construction Manager for all deliveries of leveling course material and provide load tickets prior to stockpiling or placing material. The Construction Manager will monitor leveling course stockpile throughout construction, the Contractor shall maintain a dedicated stockpile(s) for use as leveling course.

BASIS OF PAYMENT

209-5.1 Payment shall be made at the contract unit price per square yard (square meter) for crushed aggregate base course. This price shall be full compensation for furnishing all materials, for preparing and placing these materials, and for all labor, equipment tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-209-1	Crushed Aggregate Base Course (6" thick) - per square yard (square meter)
Item P-209-2	Crushed Aggregate Base Leveling Course (Contingent) - per ton

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM C29	Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C142	Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft ³ (600 kN-m/m ³))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³ (2700 kN-m/m ³))
ASTM D2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate		
ASTM D3665	Standard Practice for Random Sampling of Construction Materials		
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils		
ASTM D4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity		
ASTM D4643	Standard Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating		
ASTM D4751	Standard Test Methods for Determining Apparent Opening Size of a Geotextile		
ASTM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate		
ASTM D5821	Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate		
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)		
ASTM D7928	Standard Test Method for Particle-Size Distribution (Gradation) of Fine- Grained Soils Using the Sedimentation (Hydrometer) Analysis		
American Association of State Highway and Transportation Officials (AASHTO)			

M288 Standard Specification for Geosynthetic Specification for Highway Applications

END OF ITEM P-209

ITEM P-403 ASPHALT MIX PAVEMENT SURFACE COURSE

DESCRIPTION

403-1.1 This item shall consist of pavement courses composed of mineral aggregate and asphalt binder mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross-sections shown on the plans. Each course shall be constructed to the depth, typical section, and elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

MATERIALS

403-2.1 Aggregate. Aggregates shall consist of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. The aggregates should have no known history of detrimental pavement staining due to ferrous sulfides, such as pyrite. Coarse aggregate is the material retained on the No. 4 (4.75 mm) sieve. Fine aggregate is the material passing the No. 4 (4.75 mm) sieve.

a. Coarse aggregate. Coarse aggregate shall consist of sound, tough, durable particles, free from films of matter that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. Coarse aggregate material requirements are given in the table below.

Material Test	Requirement	Standard
Resistance to Degradation	Loss: 40% maximum for surface, asphalt binder, and leveling course	ASTM C131
	Loss: 50% maximum for base course	
Soundness of Aggregates	Loss after 5 cycles:	ASTM C88
by Use of Sodium Sulfate or	12% maximum using Sodium sulfate - or -	
Magnesium Sulfate	18% maximum using magnesium sulfate	
Clay lumps and friable particles	0.3% maximum	ASTM C142
Percentage of Fractured Particles	For pavements designed for aircraft gross weights of 60,000 pounds (27200 kg) or more:	ASTM D5821
	Minimum 75% by weight of particles with at least two fractured faces and 85% with at least one fractured face1	
Flat, Elongated, or Flat and Elongated Particles	8% maximum, by weight, of flat, elongated, or flat and elongated particles with a value of 5:1 2	ASTM D4791
Bulk density of slag ³	Weigh not less than 70 pounds per cubic foot (1.12 Mg/cubic meter)	ASTM C29.

COARSE AGGREGATE MATERIAL REQUIREMENTS

¹ The area of each face shall be equal to at least 75% of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces.

² A flat particle is one having a ratio of width to thickness greater than five (5); an elongated particle is one having a ratio of length to width greater than five (5).

³ Only required if slag is specified.

b. Fine aggregate. Fine aggregate shall consist of clean, sound, tough, durable, angular shaped particles produced by crushing stone, slag, or gravel and shall be free from coatings of clay, silt, or other objectionable matter. Natural (non-manufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. Fine aggregate material requirements are listed in the table below.

Material Test	Requirement	Standard	
Liquid limit	25 maximum	ASTM D4318	
Plasticity Index	4 maximum	ASTM D4318	
Soundness of Aggregates	Loss after 5 cycles:	ASTM C88	
by Use of Sodium Sulfate or	10% maximum using Sodium sulfate - or -		
Magnesium Sulfate	15% maximum using magnesium sulfate		
Clay lumps and friable particles	0.3% maximum	ASTM C142	
Sand equivalent	45 minimum	ASTM D2419	
Natural Sand	0 to 15% maximum by weight of total	ASTM D1073	
	aggregate		

FINE AGGREGATE MATERIAL REQUIREMENTS

c. Sampling. ASTM D75 shall be used in sampling coarse and fine aggregate, and ASTM C183 shall be used in sampling mineral filler.

403-2.2 Mineral filler. Mineral filler (baghouse fines) may be added in addition to material naturally present in the aggregate. Mineral filler shall meet the requirements of ASTM D242.

Mineral filler Requirements

Material Test	Requirement	Standard
Plasticity Index	4 maximum	ASTM D4318

403-2.3 Asphalt binder. Asphalt binder shall conform to ASTM D6373 Performance Grade (PG) 64-28NV.

Asphalt Binder PG Plus Test Requirements

Material Test	Requirement	Standard
Elastic Recovery	75% minimum	ASTM D6084

]

403-2.4 Anti-striping agent. Anti-strip shall consist of Lime Marinated aggregates prepared in accordance with the Marination Method described in Subsection 401.03.08 – Preparation of Aggregates", of the Silver Book.

COMPOSITION

403-3.1 Composition of mixture. The asphalt plant mix shall be composed of a mixture of well-graded aggregate, filler and anti-strip agent if required, and asphalt binder. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF).

403-3.2 Job mix formula (JMF) laboratory. The laboratory used to develop the JMF shall possess a current certificate of accreditation, listing D3666 from a national accrediting authority and all test methods required for developing the JMF, and listed on the accrediting authority's website. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Construction Manager prior to start of construction.

403-3.3 Job mix formula (JMF). No asphalt mixture shall be placed until an acceptable mix design has been submitted to the Construction Manager for review and accepted in writing. The Construction Manager's review shall not relieve the Contractor of the responsibility to select and proportion the materials to comply with this section.

When the project requires asphalt mixtures of differing aggregate gradations and/or binders, a separate JMF shall be submitted for each mix. Add anti-stripping agent to meet tensile strength requirements.

The JMF shall be prepared by an accredited laboratory that meets the requirements of paragraph 403-3.2. The asphalt mixture shall be designed using procedures contained in Asphalt Institute MS-2 Mix Design Manual, 7th Edition. Samples shall be prepared and compacted using a Marshall compactor in accordance with ASTM D6926.

Should a change in sources of materials be made, a new JMF must be submitted to the Construction Manager for review and accepted in writing before the new material is used. after the initial production JMF has been approved by the Construction Manager and a new or modified JMF is required for whatever reason, the subsequent cost of the new or modified JMF, including a new control strip when required by the Construction Manager, will be borne by the Contractor.

The Construction Manager may request samples at any time for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

The JMF shall be submitted in writing by the Contractor at least 15 days prior to the start of paving operations. The JMF shall be developed within the same construction season using aggregates proposed for project use.

The submitted JMF shall be dated, and stamped or sealed by the responsible professional Engineer of the laboratory and shall include the following items as a minimum:

- Manufacturer's Certificate of Analysis (COA) for the asphalt binder used in the JMF in accordance with paragraph 403-2.3. Certificate of asphalt performance grade is with modifier already added, if used and must indicate compliance with ASTM D6373. For plant modified asphalt binder, certified test report indicating grade certification of modified asphalt binder.
- Manufacturer's Certificate of Analysis (COA) for the anti-stripping agent if used in the JMF in accordance with paragraph 403-2.4.
- Certified material test reports for the course and fine aggregate and mineral filler in accordance with paragraphs 403-2.1 and 403-2.2.
- Percent passing each sieve size for individual gradation of each aggregate cold feed and/or hot bin; percent by weight of each cold feed and/or hot bin used; and the total combined gradation in the JMF.
- Specific Gravity and absorption of each course and fine aggregate.

- Percent natural sand.
- Percent fractured faces.
- Percent by weight of flat particles, elongated particles, and flat and elongated particles (and criteria).
- Percent of asphalt.
- Number of blows or gyrations.
- Laboratory mixing and compaction temperatures.
- Supplier recommended mixing and compaction temperatures.
- Plot of the combined gradation on the 0.45 power gradation curve.
- Graphical plots of air voids, voids in the mineral aggregate (VMA), and unit weight versus asphalt content. To achieve minimum VMA during production, the mix design needs to account for material breakdown during production.
- Tensile Strength Ratio (TSR).
- Type and amount of Anti-strip agent when used.
- Asphalt Pavement Analyzer (APA) results.
- Date the JMF was developed. Mix designs that are not dated or which are from a prior construction season shall not be accepted.
- Percentage and properties (asphalt content, asphalt binder properties, and aggregate properties) of reclaimed asphalt pavement (RAP) in accordance with paragraph 403-3.4, Reclaimed Hot-Mix Asphalt, if RAP is used.

Table 1. Asphalt Design Criteria

Test Property	Value	Test Method	
Number of blows	75		
Air voids (%)	3.5	ASTM D3203	
Percent voids in mineral aggregate (VMA), minimum	See Table 2	ASTM D6995	
TSR ¹	not less than 80 at a saturation of 70-80%	ASTM D4867	
Asphalt Pavement Analyzer (APA) ²	Less than 10 mm @ 4000 passes	AASHTO T340 at 250 psi hose pressure at 64°C test temperature	

¹ Test specimens for TSR shall be compacted at 7 ± 1.0 % air voids. In areas subject to freeze-thaw, use freeze-thaw conditioning in lieu of moisture conditioning per ASTM D4867.

² AASHTO T340 at 100 psi hose pressure at 64°C test temperature may be used in the interim. If this method is used the required Value shall be less than 5 mm @ 8000 passes

The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation or gradations specified in Table 2 when tested in accordance with ASTM C136 and ASTM C117.

The gradations in Table 2 represent the limits that shall determine the suitability of aggregate for use from the sources of supply, be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa.

Sieve Size	Percentage by Weight Passing Sieve	
1 inch (25.0 mm)		
3/4 inch (19.0 mm)	100	
1/2 inch (12.5 mm)	90-100	
3/8 inch (9.5 mm)	72-88	
No. 4 (4.75 mm)	53-73	
No. 8 (2.36 mm)	38-60	
No. 16 (1.18 mm)	26-48	
No. 30 (600 μm)	18-38	
No. 50 (300 μm)	11-27	
No. 100 (150 μm)	6-18	
No. 200 (75 μm)	3-6	
Voids in Mineral Aggregate (VMA) ¹	15	
Asphalt Percent:		
Stone or gravel	5.0-7.5	
Slag	6.5-9.5	
Recommended Minimum Construction Lift Thickness	2 inch	

Table 2. Aggregate - Asphalt Pavements

¹To achieve minimum VMA during production, the mix design needs to account for material breakdown during production.

The aggregate gradations shown are based on aggregates of uniform specific gravity. The percentages passing the various sieves shall be corrected when aggregates of varying specific gravities are used, as indicated in the Asphalt Institute MS-2 Mix Design Manual, 7th Edition.

403-3.4 Reclaimed asphalt pavement (RAP). Reclaimed asphalt pavement shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt. Recycled asphalt shingles (RAS) shall not be allowed. The RAP shall be of a consistent gradation and asphalt content and properties. When RAP is fed into the plant, the maximum RAP chunk size shall not exceed 1-1/2 inches (38 mm). The reclaimed asphalt mix shall be designed using procedures contained in the Asphalt Institute MS-2 Mix Design Manual, 7th Edition. The percentage of asphalt in the RAP shall be established for the mixture design according to ASTM D2172 using the appropriate dust correction procedure. The JMF shall meet the requirements of paragraph 403-3.3. RAP should only be used for shoulder surface course mixes and for any intermediate courses. The use of RAP containing Coal Tar shall not be allowed. Coal Tar surface treatments must be removed prior to recycling underlying asphalt material. The amount of RAP shall be limited to 15 percent.

403-3.5 Control strip. Full production shall not begin until an acceptable control strip has been constructed and accepted in writing by the Construction Manager. The Contractor shall prepare and place a quantity of asphalt according to the JMF. The underlying grade or pavement structure upon which the control strip is to be constructed shall be the same as the remainder of the course represented by the control strip.

The Contractor will not be allowed to place the control strip until the Contractor quality control program (CQCP), showing conformance with the requirements of paragraph 403-5.1, has been accepted, in writing, by the Construction Manager.

The control strip will consist of at least 250 tons (227 metric tons) or 1/2 sublot, whichever is greater. The control strip shall be placed in two lanes of the same width and depth to be used in production with a longitudinal cold joint. The cold joint must be cut back in accordance with paragraph 403-4.13 using the same procedure that will be used during production. The cold joint for the control strip will be an exposed construction joint at least four (4) hours old or when the mat has cooled to less than 160°F (71°C). The equipment used in construction of the control strip shall be the same type, configuration and weight to be used on the project.

The control strip shall be evaluated for acceptance as a single lot in accordance with the acceptance criteria in paragraph 403-6.1 and 403-6.2. The control strip shall be divided into equal sublots. As a minimum, the control strip shall consist of three (3) sublots.

The control strip will be considered acceptable by the Construction Manager if the gradation, asphalt content, and VMA are within the action limits specified in paragraph 403-5.5a; and Mat density, air voids, and joint density meet the requirements specified in paragraphs 403-6.2.

If the control strip is unacceptable, necessary adjustments to the JMF, plant operation, placing procedures, and/or rolling procedures shall be made and another control strip shall be placed. Unacceptable control strips shall be removed at the Contractor's expense.

Payment will only be made for an acceptable control strip in accordance with paragraph 403-8.1.

CONSTRUCTION METHODS

403-4.1 Weather limitations. The asphalt shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 4. The temperature requirements may be waived by the CONSTRUCTION MANAGER, if requested; however, all other requirements including compaction shall be met.

Mat Thiskness	Base Temperature (Minimum)		
Mat Inickness	Degrees F	Degrees C	
3 inches (7.5 cm) or greater	40	4	
Greater than 2 inches (50 mm)	45	7	
but less than 3 inches (7.5 cm)			

Table 4.	Surface '	Temperature	Limitations	of Une	derlying	Course
	Surface	i cinper acure	Limitations	UI UII	ucitying	Course

403-4.2 Asphalt plant. Plants used for the preparation of asphalt shall conform to the requirements of American Association of State Highway and Transportation Officials (AASHTO) M156 including the following items:

a. Inspection of plant. The Construction Manager, or Construction Manager's authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant: verifying weights, proportions, and material properties; and checking the temperatures maintained in the preparation of the mixtures.

b. Storage bins and surge bins. The asphalt mixture stored in storage and/or surge bins shall meet the same requirements as asphalt mixture loaded directly into trucks. Asphalt mixture shall not be stored in storage and/or surge bins for a period greater than twelve (12) hours. If the CONSTRUCTION MANAGER determines there is an excessive heat loss, segregation or oxidation of the asphalt mixture due to temporary storage, temporary storage shall not be allowed.

403-4.3 Aggregate stockpile management. Aggregate stockpiles shall be constructed in such a manner that prevents segregation and intermixing of deleterious materials. Aggregates from different sources shall be stockpiled, weighed and batched separately at the concrete batch plant. Aggregates that have become segregated or mixed with earth or foreign material shall not be used.

A continuous supply of materials shall be provided to the work to ensure continuous placement.

403-4.4 Hauling equipment. Trucks used for hauling asphalt shall have tight, clean, and smooth metal beds. To prevent the asphalt from sticking to the truck beds, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other material approved by the Construction Manager. Petroleum products shall not be used for coating truck beds. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

403-4.4.1 Material transfer vehicle (MTV). At the contractor's option, material transfer vehicles may be used due to the improvement in smoothness and decrease in both physical and thermal segregation. To transfer the material from the hauling equipment to the paver, use a self-propelled, material transfer vehicle with a swing conveyor that can deliver material to the paver without making contact with the paver. The MTV shall be able to move back and forth between the hauling equipment and the paver providing material transfer to the paver, while allowing the paver to operate at a constant speed. The Material Transfer Vehicle will have remixing and storage capability to prevent physical and thermal segregation.

403-4.5 Asphalt pavers. Asphalt pavers shall be self-propelled with an activated heated screed, capable of spreading and finishing courses of asphalt that will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface. The asphalt paver shall be equipped with a control system capable of automatically maintaining the specified screed grade and elevation.

If the spreading and finishing equipment in use leaves tracks or indented areas, or produces other blemishes in the pavement that are not satisfactorily corrected by the scheduled operations, the use of such equipment shall be discontinued.

The paver shall be capable of paving to a minimum width specified in paragraph 401-4.11.

403-4.6 Rollers. The number, type, and weight of rollers shall be sufficient to compact the asphalt to the required density while it is still in a workable condition without crushing of the aggregate, depressions or other damage to the pavement surface. Rollers shall be in good condition, capable of operating at slow speeds to avoid displacement of the asphalt. All rollers shall be specifically designed and suitable for compacting asphalt concrete and shall be properly used. Rollers that impair the stability of any layer of a pavement structure or underlying soils shall not be used.

403-4.6.1 Density device. The Contractor shall have on site a density gauge during all paving operations in order to assist in the determination of the optimum rolling pattern, type of roller and frequencies, as well as to monitor the effect of the rolling operations during production paving. The Contractor shall also supply a qualified technician during all paving operations to calibrate the density gauge and obtain accurate density readings for all new asphalt. These densities shall be supplied to the Construction Manager upon request at any time during construction. No separate payment will be made for supplying the density gauge and technician.

403-4.7 Preparation of asphalt binder. The asphalt binder shall be heated in a manner that will avoid local overheating and provide a continuous supply of the asphalt material to the mixer at a uniform temperature. The temperature of the unmodified asphalt binder delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed $325^{\circ}F$ (160°C) when added to the aggregate. The temperature of modified asphalt binder shall be no more than $350^{\circ}F$ (175°C) when added to the aggregate.

403-4.8 Preparation of mineral aggregate. The aggregate for the asphalt shall be heated and dried. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. The temperature of the aggregate and mineral filler shall not exceed 350°F (175°C) when the asphalt binder is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

403-4.9 Preparation of asphalt mixture. The aggregates and the asphalt binder shall be weighed or metered and introduced into the mixer in the amount specified by the JMF. The combined materials shall be mixed until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the Contractor, based on the procedure for determining the percentage of coated particles described in ASTM D2489, for each individual plant and for each type of aggregate used. The wet mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer. The moisture content of all asphalt upon discharge shall not exceed 0.5%.

403-4.10 Application of prime and tack coat. Immediately before placing the asphalt mixture, the underlying course shall be cleaned of all dust and debris.

A prime coat in accordance with Item P-602 shall be applied to aggregate base prior to placing the asphalt mixture.

A tack coat shall be applied in accordance with Item P-603 to all vertical and horizontal asphalt and concrete surfaces prior to placement of the first and each subsequent lift of asphalt mixture.

403-4.11 Laydown plan, transporting, placing, and finishing. Prior to the placement of the asphalt, the Contractor shall prepare a laydown plan with the sequence of paving lanes and width to minimize the number of cold joints; the location of any temporary ramps; laydown temperature; and estimated time of completion for each portion of the work (milling, paving, rolling, cooling, etc.). The laydown plan and any modifications shall be approved by the Construction Manager.

Deliveries shall be scheduled so that placing and compacting of asphalt is uniform with minimum stopping and starting of the paver. Hauling over freshly placed material shall not be permitted until the material has

been compacted, as specified, and allowed to cool to approximately ambient temperature. The Contractor, at their expense, shall be responsible for repair of any damage to the pavement caused by hauling operations.

Contractor shall survey each lift of asphalt surface course and certify to Construction Manager that every lot of each lift meets the grade tolerances of paragraph 401-6.2e before the next lift can be placed.

Edges of existing asphalt pavement abutting the new work shall be saw cut and the cut off material and laitance removed. Apply a tack coat in accordance with P-603 before new asphalt material is placed against it.

The speed of the paver shall be regulated to eliminate pulling and tearing of the asphalt mat. Placement of the asphalt mix shall begin along the centerline of a crowned section or on the high side of areas with a one way slope unless shown otherwise on the laydown plan as accepted by the Construction Manager. The asphalt mix shall be placed in consecutive adjacent lanes having a minimum width of 15 feet (m) except where edge lanes require less width to complete the area. Additional screed sections attached to widen the paver to meet the minimum lane width requirements must include additional auger sections to move the asphalt mixture uniformly along the screed extension.

The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1 foot (30 cm); however, the joint in the surface top course shall be at the centerline of crowned pavements. Transverse joints in one course shall be offset by at least 10 feet (3 m) from transverse joints in the previous course. Transverse joints in adjacent lanes shall be offset a minimum of 10 feet (3 m).On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the asphalt may be spread and luted by hand tools.

The Construction Manager may at any time, reject any batch of asphalt, on the truck or placed in the mat, which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or overheated asphalt mixture. Such rejection may be based on only visual inspection or temperature measurements. In the event of such rejection, the Contractor may take a representative sample of the rejected material in the presence of the Construction Manager, and if it can be demonstrated in the laboratory, in the presence of the Construction Manager, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

Areas of segregation in the surface course, as determined by the Construction Manager, shall be removed and replaced at the Contractor's expense. The area shall be removed by saw cutting and milling a minimum of the construction lift thickness as specified in paragraph 401-3.3, Table 2 for the approved mix design. The area to be removed and replaced shall be a minimum width of the paver and a minimum of 10 feet (3 m) long.

403-4.12 Compaction of asphalt mixture. After placing, the asphalt mixture shall be thoroughly and uniformly compacted by self-propelled rollers. The surface shall be compacted as soon as possible when the asphalt has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any surface defects and/or displacement occurring as a result of the roller, or from any other cause, shall be corrected at the Contractor's expense.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross-section, and the required field density is obtained. To prevent adhesion of the asphalt to the roller, the wheels shall be equipped with a scraper and kept moistened with water as necessary.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with approved power tampers.

Any asphalt that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching shall not be allowed.

403-4.13 Joints. The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

The roller shall not pass over the unprotected end of the freshly laid asphalt except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. In both methods, all contact surfaces shall be coated with an asphalt tack coat before placing any fresh asphalt against the joint.

Longitudinal joints which are have been left exposed for more than four (4) hours; the surface temperature has cooled to less than 175°F (80°C); or are irregular, damaged, uncompacted or otherwise defective shall be cut back with a cutting wheel or pavement saw a maximum of 3 inches (75 mm) to expose a clean, sound, uniform vertical surface for the full depth of the course. All cutback material and any laitance produced from cutting joints shall be removed from the project. An asphalt tack coat or other product approved by the Construction Manager shall be applied to the clean, dry joint prior to placing any additional fresh asphalt against the joint. The cost of this work shall be considered incidental to the cost of the asphalt.

The Contractor may provide additional joint density QC by use of joint heaters at the Contractor's expense. Electrically powered infrared heating equipment should consist of one or more low-level radiant energy heaters to uniformly heat and soften the pavement joints. The heaters should be configured to uniformly heat an area up to 18 inches (0.5 m) in width and 3 inches (75 mm) in depth. Infrared equipment shall be thermostatically controlled to provide a uniform, consistent temperature increase throughout the layer being heated up to a maximum temperature range of 200° F to 300° F (93° C to 150° C).

Propane powered infrared heating equipment shall be attached to the paving machine and the output of infrared energy shall be in the one to six-micron range. Converters shall be arranged end to end directly over the joint to be heated in sufficient numbers to continuously produce, when in operation, a minimum of 240,000 BTU per hour. The joint heater shall be positioned not more than one inch (25 mm) above the pavement to be heated and in front of the paver screed and shall be fully adjustable. Heaters will be required to be in operation at all times.

The heaters shall be operated so they do not produce excessive heat when the units pass over new or previously paved material.

403-4.14 Saw-cut grooving. Saw-cut grooving is not required

403-4.15 Diamond grinding. Diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive.

Diamond grinding shall be performed with a machine designed specifically for diamond grinding capable of cutting a path at least 3 feet (0.9 m) wide. The saw blades shall be 1/8-inch (3-mm) wide with a minimum of 55 to 60 blades per 12 inches (300 mm) of cutting head width; grooves between 0.090 and 0.130 inches

(2 and 3.5 mm) wide; and peaks and ridges approximately 1/32 inch (1 mm) higher than the bottom of the grinding cut. The actual number of blades will be determined by the Contractor and depend on the hardness of the aggregate. Equipment or grinding procedures that causes ravels, aggregate fractures, spalls or disturbance to the pavement will not be permitted.

Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The slurry resulting from the grinding operation shall be continuously removed and the pavement left in a clean condition. The Contractor shall apply a surface treatment per P-608 to all areas that have been subject to grinding.

403-4.16 Nighttime paving requirements. The Contractor shall provide adequate lighting during any nighttime construction. A lighting plan shall be submitted by the Contractor and approved by the Construction Manager prior to the start of any nighttime work. All work shall be in accordance with the approved CSPP and lighting plan.

CONTRACTOR QUALITY CONTROL (CQC)

403-5.1 General. The Contractor shall develop a CQCP in accordance with Item C-100. No partial payment will be made for materials that are subject to specific QC requirements without an approved CQCP.

403-5.2 Contractor quality control (QC) facilities. The Contractor shall provide or contract for testing facilities in accordance with Item C-100. The Construction Manager shall be permitted unrestricted access to inspect the Contractor's QC facilities and witness QC activities. The Construction Manager will advise the Contractor in writing of any noted deficiencies concerning the QC facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting the test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

403-5.3 Quality control (QC) testing. The Contractor shall perform all QC tests necessary to control the production and construction processes applicable to these specifications and as set forth in the approved CQCP. The testing program shall include, but not necessarily be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, field compaction, and surface smoothness. A QC Testing Plan shall be developed as part of the CQCP.

a. Asphalt content. A minimum of two tests shall be performed per day in accordance with ASTM D6307 or ASTM D2172 for determination of asphalt content. When using ASTM D6307, the correction factor shall be determined as part of the first test performed at the beginning of plant production; and as part of every tenth test performed thereafter. The asphalt content for the day will be determined by averaging the test results.

b. Gradation. Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with ASTM D5444 and ASTM C136, and ASTM C117.

c. Moisture content of aggregate. The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C566.

d. Moisture content of asphalt. The moisture content of the asphalt shall be determined once per lot in accordance with AASHTO T329 or ASTM D1461.

e. Temperatures. Temperatures shall be checked, at least four times per lot, at necessary locations to determine the temperatures of the dryer, the asphalt binder in the storage tank, the asphalt at the plant, and the asphalt at the job site.

f. In-place density monitoring. The Contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D2950.

g. Smoothness for Contractor Quality Control.

The Contractor shall perform smoothness testing in transverse and longitudinal directions daily to verify that the construction processes are producing pavement with variances less than ¹/₄ inch in 12 feet, identifying areas that may pond water which could lead to hydroplaning of aircraft. If the smoothness criteria is not met, appropriate changes and corrections to the construction process shall be made by the Contractor before construction continues

The Contractor may use a 12-foot (3.7 m) straightedge, a rolling inclinometer meeting the requirements of ASTM E2133 or rolling external reference device that can simulate a 12-foot (3.7m) straightedge approved by the Engineer. Straight-edge testing shall start with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. Testing shall be continuous across all joints. The surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between the two high points. If the rolling inclinometer or external reference device is used, the data may be evaluated using the FAA profile program, ProFAA, using the 12-foot straightedge simulation function.

Smoothness readings shall not be made across grade changes or cross slope transitions. The transition between new and existing pavement shall be evaluated separately for conformance with the plans.

(1) **Transverse measurements.** Transverse measurements shall be taken for each day's production placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50 feet (15 m) or more often as determined by the Construction Manager. The joint between lanes shall be tested separately to facilitate smoothness between lanes.

(2) Longitudinal measurements. Longitudinal measurements shall be taken for each day's production placed. Longitudinal tests will be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20 feet (6 m); and at the third points of paving lanes when widths of paving lanes are 20 ft (6 m) or greater.

Deviations on the final surface course in either the transverse or longitudinal direction that will trap water greater than 1/4 inch (6 mm) shall be corrected with diamond grinding per paragraph 403-4.15 or by removing and replacing the surface course to full depth. Grinding shall be tapered in all directions to provide smooth transitions to areas not requiring grinding. All areas in which diamond grinding has been performed shall be subject to the final pavement thickness tolerances specified in paragraph 401-6.1d(3) Areas that have been ground shall be sealed with a surface treatment in accordance with Item P-608. To avoid the surface treatment creating any conflict with runway or taxiway markings, it may be necessary to seal a larger area.

Control charts shall be kept to show area of each day's placement and the percentage of corrective grinding required. Corrections to production and placement shall be initiated when corrective grinding is required. If the Contractor's machines and/or methods produce significant areas that need corrective actions in excess of 10 percent of a day's production, production shall be stopped until corrective measures are implemented by the Contractor.

h. Grade. Grade shall be evaluated daily to allow adjustments to paving operations when grade measurements do not meet specifications. As a minimum, grade shall be evaluated prior to the placement of the first lift and then prior to and after placement of the surface lift.

Measurements will be taken at appropriate gradelines (as a minimum at center and edges of paving lane) and longitudinal spacing as shown on cross-sections and plans. The final surface of the pavement will not vary from the gradeline elevations and cross-sections shown on the plans by more than 1/2 inch (12 mm) vertically and 0.1 feet (30 mm) laterally. The documentation will be provided by the Contractor to the Construction Manager by the end of the following working day.

Areas with humps or depressions that exceed grade or smoothness criteria and that retain water on the surface must be ground off provided the course thickness after grinding is not more than 1/2 inch (12 mm) less than the thickness specified on the plans. Grinding shall be in accordance with paragraph 403-4.15.

The Contractor shall repair low areas or areas that cannot be corrected by grinding by removal of deficient areas to the depth of the final course plus $\frac{1}{2}$ inch and replacing with new material. Skin patching is not allowed.

403-5.4 Sampling. When directed by the Construction Manager, the Contractor shall sample and test any material that appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

403-5.5 Control charts. The Contractor shall maintain linear control charts both for individual measurements and range (i.e., difference between highest and lowest measurements) for aggregate gradation, asphalt content, and VMA. The VMA for each day shall be calculated and monitored by the QC laboratory.

Control charts shall be posted in a location satisfactory to the Construction Manager and kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a problem and the Contractor is not taking satisfactory corrective action, the Construction Manager may suspend production or acceptance of the material.

a. Individual measurements. Control charts for individual measurements shall be established to maintain process control within tolerance for aggregate gradation, asphalt content, and VMA. The control charts shall use the JMF target values as indicators of central tendency for the following test parameters with associated Action and Suspension Limits:
Sieve	Action Limit	Suspension Limit
3/4 inch (19.0 mm)	±6%	±9%
1/2 inch (12.5 mm)	±6%	±9%
3/8 inch (9.5 mm)	±6%	±9%
No. 4 (4.75 mm)	±6%	±9%
No. 16 (1.18 mm)	±5%	±7.5%
No. 50 (300 µm)	±3%	±4.5%
No. 200 (75 µm)	±2%	±3%
Asphalt Content	±0.45%	±0.70%
Minimum VMA	-0.5%	-1.0%

Control Chart Limits for Individual Measurements

b. Range. Control charts for range shall be established to control process variability for the test parameters and Suspension Limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameter. The Suspension Limits specified below are based on a sample size of n = 2. Should the Contractor elect to perform more than two tests per lot, the Suspension Limits shall be adjusted by multiplying the Suspension Limit by 1.18 for n = 3 and by 1.27 for n = 4.

Control Chart Limits Based on Range (n = 2)

Sieve	Suspension Limit
1/2 inch (12.5 mm)	11%
3/8 inch (9.5 mm)	11%
No. 4 (4.75 mm)	11%
No. 16 (1.18 mm)	9%
No. 50 (300 μm)	6%
No. 200 (75 μm)	3.5%
Asphalt Content	0.8%

c. Corrective action. The CQCP shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The Plan shall contain sets of rules to gauge when a process is out of control and detail what action will be taken to bring the process into control. As a minimum, a process shall be deemed out of control and production stopped and corrective action taken, if:

(1) One point falls outside the Suspension Limit line for individual measurements or range;

(2) Two points in a row fall outside the Action Limit line for individual measurements.

403-5.6 Quality control (QC) reports. The Contractor shall maintain records and shall submit reports of QC activities daily, in accordance with the CQCP described in Item C-100.

or

MATERIAL ACCEPTANCE

403-6.1. Quality assurance acceptance sampling and testing. Unless otherwise specified, all acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be performed by the Construction Manager at no cost to the Contractor except that coring as required in this section shall be completed and paid for by the Contractor.

a. Quality Assurance (QA) testing laboratory. The QA testing laboratory performing these acceptance tests will be accredited in accordance with ASTM D3666. The QA laboratory accreditation will be current and listed on the accrediting authority's website. All test methods required for acceptance sampling and testing will be listed on the lab accreditation.

b. Lot Size. A standard lot will be equal to one day's production divided into approximately equal sublots of between 400 to 600 tons. When only one or two sublots are produced in a day's production, the sublots will be combined with the production lot from the previous or next day.

Where more than one plant is simultaneously producing asphalt for the job, the lot sizes will apply separately for each plant.

c. Asphalt air voids. Plant-produced asphalt will be tested for air voids on a sublot basis.

(1) Sampling. Material from each sublot shall be sampled in accordance with ASTM D3665. Samples shall be taken from material deposited into trucks at the plant or at the job site in accordance with ASTM D979. The sample of asphalt may be put in a covered metal tin and placed in an oven for not less than 60 minutes nor more than 90 minutes to maintain the material at or above the compaction temperature as specified in the JMF.

(2) Testing. Air voids will be determined for each sublot in accordance with ASTM D3203 for a set of compacted specimens prepared in accordance with ASTM D6926.

d. In-place asphalt mat and joint density. Each sublot will be tested for in-place mat and joint density as a percentage of the theoretical maximum density (TMD).

(1) Sampling. The Contractor will cut minimum 5 inches (125 mm) diameter samples in accordance with ASTM D5361. The Contractor shall furnish all tools, labor, and materials for cleaning, and filling the cored pavement. Laitance produced by the coring operation shall be removed immediately after coring, and core holes shall be filled within one day after sampling in a manner acceptable to the Construction Manager.

(2) Bond. Each lift of asphalt shall be bonded to the underlying layer. If cores reveal that the surface is not bonded, additional cores shall be taken as directed by the Construction Manager to determine the extent of unbonded areas. Unbonded areas shall be removed by milling and replaced at no additional cost as directed by the Construction Manager.

(3) Thickness. Thickness of each lift of surface course will be evaluated by the Construction Manager for compliance to the requirements shown on the plans after any necessary corrections for grade. Measurements of thickness will be made using the cores extracted for each sublot for density measurement. The maximum allowable deficiency at any point will not be more than 1/4 inch (6 mm) less than the thickness indicated for the lift. Average thickness of lift, or combined lifts, will not be less than the indicated thickness. Where the thickness tolerances are not met, the lot or sublot shall be corrected by the Contractor at his expense by removing the deficient area and replacing with new pavement. The Contractor, at his expense, may take additional cores as approved by the Construction Manager to circumscribe the deficient area.

(4) Mat density. One core shall be taken from each sublot. Core locations will be determined by the Construction Manager in accordance with ASTM D3665. Cores for mat density shall not be taken closer than one foot (30 cm) from a transverse or longitudinal joint. The bulk specific gravity of each cored sample will be determined in accordance with ASTM D2726. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each sublot sample by the TMD for that sublot.

(5) Joint density. One core centered over the longitudinal joint shall be taken for each sublot which contains a longitudinal joint. Core locations will be determined by the Construction Manager in accordance with ASTM D3665. The bulk specific gravity of each core sample will be determined in accordance with ASTM D2726. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each joint density sample by the average TMD for the lot. The TMD used to determine the joint density at joints formed between lots will be the lower of the average TMD values from the adjacent lots.

403-6.2 Acceptance criteria.

a. General. Acceptance will be based on the implementation of the Contractor Quality Control Program (CQCP) and the following characteristics of the asphalt and completed pavements: air voids, mat density, joint density and grade.

b. Air voids. Acceptance of each lot of plant produced material for air voids will be based upon the average air void from the sublots. If the average air voids of the lot are equal to or greater than 2% and equal to or less than 5%, then the lot will be acceptable. If the average is below 2% or greater than 5%, the lot shall be removed and replaced at the Contractor's expense.

c. Mat density. Acceptance of each lot of plant produced material for mat density will be based on the average of all of the densities taken from the sublots. If the average mat density of the lot so established equals or exceeds 94%, the lot will be acceptable. If the average mat density of the lot is below 94%, the lot shall be removed and replaced at the Contractor's expense.

d. Joint density. Acceptance of each lot of plant produced asphalt for joint density will be based on the average of all of the joint densities taken from the sublots. If the average joint density of the lot so established equals or exceeds 92%, the lot will be acceptable. If the average joint density of the lot is less than 92%, the Contractor shall stop production and evaluate the method of compacting joints. Production may resume once the reason for poor compaction has been determined and appropriate measures have been taken to ensure proper compaction.

e. Grade. The final finished surface of the pavement of the completed project shall be surveyed to verify that the grade elevations and cross-sections shown on the plans do not deviate more than 1/2 inch (12 mm) vertically or 0.1 feet (30 mm) laterally.

Cross-sections of the pavement shall be taken at a minimum 50-foot (15-m) longitudinal spacing and at all longitudinal grade breaks. Minimum cross-section grade points shall include grade at edge of shoulder, and edge of runway or taxiway pavement.

The survey and documentation shall be stamped and signed by a licensed surveyor. Payment for sublots that do not meet grade for over 25% of the sublot shall not be more than 95%.

403-6.3 Resampling pavement for mat density.

a. General. Resampling of a lot of pavement will only be allowed for mat density and then, only if the Contractor requests same in writing, within 48 hours after receiving the written test results from the

Construction Manager. A retest will consist of all the sampling and testing procedures contained in paragraphs 403-6.1. Only one resampling per lot will be permitted.

(1) A redefined mat density will be calculated for the resampled lot. The number of tests used to calculate the redefined mat density will include the initial tests made for that lot plus the retests.

(2) The cost for resampling and retesting shall be borne by the Contractor.

b. Payment for resampled lots. The redefined mat density for a resampled lot will be used to evaluate the acceptance of that lot in accordance with paragraph 403-6.2.

c. Outliers. Check for outliers in accordance with ASTM E178, at a significance level of 5%. Outliers will be discarded and density determined using the remaining test values.

METHOD OF MEASUREMENT

403-7.1 Measurement. Plant mix asphalt mix pavement shall be measured by the number of square yards (square meters), at the specified thickness, of asphalt pavement placed calculated on the basis of the dimensions shown on the contract drawings or as adjusted by the amount of any changed ordered by the Owner. No allowance will be made for material placed outside said dimensions unless ordered by the Owner.

BASIS OF PAYMENT

403-8.1 Payment. Payment for a lot of asphalt mixture meeting all acceptance criteria as specified in paragraph 403-6.2 shall be made at the contract unit price per square yard (square meter) for asphalt. The price shall be compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-403-1Asphalt Mix Pavement Surface Course (6 inch thick) – square yard (square meter)Item P-403-2Asphalt Mix Pavement Base Course (6 inch thick) – square yard (square meter)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM C29	Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

ASTM C117	Standard Test Method for Materials Finer than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127	Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C142	Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C183	Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement
ASTM C566	Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D242	Standard Specification for Mineral Filler for Bituminous Paving Mixtures
ASTM D946	Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D979	Standard Practice for Sampling Bituminous Paving Mixtures
ASTM D1073	Standard Specification for Fine Aggregate for Bituminous Paving Mixtures
ASTM D1074	Standard Test Method for Compressive Strength of Bituminous Mixtures
ASTM D1461	Standard Test Method for Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D2041	Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D2172	Standard Test Method for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM D2489	Standard Practice for Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures
ASTM D2726	Standard Test Method for Bulk Specific Gravity and Density of Non- Absorptive Compacted Bituminous Mixtures

ASTM D2950	Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D3203	Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
ASTM D3381	Standard Specification for Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D3666	Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4125	Standard Test Methods for Asphalt Content of Bituminous mixtures by the Nuclear Method
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4552	Standard Practice for Classifying Hot-Mix Recycling Agents
ASTM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D4867	Standard Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D5444	Standard Test Method for Mechanical Size Analysis of Extracted Aggregate
ASTM D5581	Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (6 inch-Diameter Specimen)
ASTM D5821	Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6307	Standard Test Method for Asphalt Content of Hot-Mix Asphalt by Ignition Method
ASTM D6373	Standard Specification for Performance Graded Asphalt Binder
ASTM D6752	Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing Method
ASTM D6925	Standard Test Method for Preparation and Determination of the Relative Density of Hot Mix Asphalt (HMA) Specimens by Means of the SuperPave Gyratory Compactor
ASTM D6926	Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus

ASTM D6927	Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures		
ASTM D6995	Standard Test Method for Determining Field VMA based on the Maximum Specific Gravity of the Mix (Gmm)		
ASTM E11	Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves		
ASTM E178	Standard Practice for Dealing with Outlying Observations		
ASTM E2133	Standard Test Method for Using a Rolling Inclinometer to Measure Longitudinal and Transverse Profiles of a Traveled Surface		
American Association of State	Highway and Transportation Officials (AASHTO)		
AASHTO M156	Standard Specification for Requirements for Mixing Plants for Hot- Mixed, Hot-Laid Bituminous Paving Mixtures		
AASHTO T329	Standard Method of Test for Moisture Content of Hot Mix Asphalt (HMA) by Oven Method		
AASHTO T 340	Standard Method of Test for Determining the Rutting Susceptibility of Hot Mix Asphalt (APA) Using the Asphalt Pavement Analyzer (APA)		
Asphalt Institute (AI)			
MS-2	Mix Design Manual, 7th Edition		
MS-26	AsphaltBinderHandbookAI State Binder Specification Database		
FAA Orders			
5300.1	Modifications to Agency Airport Design, Construction, and Equipment Standards		
Federal Highway Administration (FHWA)			
Long Term Pavement Performance Binder program			
Software			

FAARFIELD

END OF ITEM P-403

ITEM P-501 CEMENT CONCRETE PAVEMENT

DESCRIPTION

501-1.1 This work shall consist of pavement composed of cement concrete without reinforcement constructed on a prepared underlying surface in accordance with these specifications and shall conform to the lines, grades, thickness, and typical cross-sections shown on the plans. The terms cement concrete, hydraulic cement concrete, and concrete are interchangeable in this specification.

MATERIALS

501-2.1 Aggregates.

a. Reactivity. Fine and Coarse aggregates to be used in PCC on this project shall be tested and evaluated by the Contractor for alkali-aggregate reactivity in accordance with both ASTM C1260 and ASTM C1567. Tests must be representative of aggregate sources which will be providing material for production. ASTM C1260 and ASTM C1567 tests may be run concurrently.

(1) Coarse aggregate and fine aggregate shall be tested separately in accordance with ASTM C1260, however, the length of test shall be extended to 28 days (30 days from casting). Tests must have been completed within 6 months of the date of the concrete mix submittal.

(2) The combined coarse and fine aggregate shall be tested in accordance with ASTM C1567, modified for combined aggregates, using the proposed mixture design proportions of aggregates, cementitious materials, and/or specific reactivity reducing chemicals. If the expansion does not exceed 0.10% at 28 days, the proposed combined materials will be accepted. If the expansion is greater than 0.10% at 28 days, the aggregates will not be accepted unless adjustments to the combined materials mixture can reduce the expansion to less than 0.10% at 28 days, or new aggregates shall be evaluated and tested.

(3) If lithium nitrate is proposed for use with or without supplementary cementitious materials, the aggregates shall be tested in accordance with Corps of Engineers (COE) Concrete Research Division (CRD) C662 in lieu of ASTM C1567. If lithium nitrate admixture is used, it shall be nominal $30\% \pm 0.5\%$ weight lithium nitrate in water. If the expansion does not exceed 0.10% at 28 days, the proposed combined materials will be accepted. If the expansion is greater than 0.10% at 28 days, the aggregates will not be accepted unless adjustments to the combined materials mixture can reduce the expansion to less than 0.10% at 28 days, or new aggregates shall be evaluated and tested.

b. Fine aggregate. Grading of the fine aggregate, as delivered to the mixer, shall conform to the requirements of ASTM C33 and the parameters identified in the fine aggregate material requirements below. Fine aggregate material requirements and deleterious limits are shown in the table below.

Fine Aggregate Material Requirements			
Soundness of Aggregates	Loss after 5 cycles:	ASTM C88	
by Use of Sodium Sulfate or	10% maximum using Sodium sulfate - or -		
Magnesium Sulfate	15% maximum using magnesium sulfate		
Sand Equivalent	45 minimum	ASTM D2419	
Fineness Modulus (FM)	$2.50 \leq FM \leq 3.40$	ASTM C136	
Limits for Deleterious Substances in Fine Aggregate for Concrete			
Clay lumps and friable particles	1.0% maximum	ASTM C142	
Coal and lignite	0.5% using a medium with a density of Sp. Gr. of 2.0	ASTM C123	
Total Deleterious Material	1.0% maximum		

c. Coarse aggregate. The maximum size coarse aggregate shall be 2-inch.

Aggregates delivered to the mixer shall be clean, hard, uncoated aggregates consisting of crushed stone, crushed or uncrushed gravel, air-cooled iron blast furnace slag, crushed recycled concrete pavement, or a combination. The aggregates shall have no known history of detrimental pavement staining. Steel blast furnace slag shall not be permitted. Coarse aggregate material requirements and deleterious limits are shown in the table below; washing may be required to meet aggregate requirements.

Coarse Aggregate Material Requirements

Material Test	Requirement	Standard
Resistance to Degradation	Loss: 40% maximum	ASTM C131
Soundness of Aggregates	Loss after 5 cycles:	ASTM C88
by Use of Sodium Sulfate or	12% maximum using Sodium sulfate - or -	
Magnesium Sulfate	18% maximum using magnesium sulfate	
Flat, Elongated, or Flat and Elongated Particles	8% maximum, by weight, of flat, elongated, or flat and elongated particles at 5:1 for any size group coarser than 3/8 (9.5 mm) sieve ¹	ASTM D4791
Bulk density of slag ²	Weigh not less than 70 pounds per cubic foot (1.12 Mg/cubic meter)	ASTM C29
D-cracking (Freeze-Thaw) ³	Durability factor ≥ 95	ASTM C666

¹ A flat particle is one having a ratio of width to thickness greater than five (5); an elongated particle is one having a ratio of length to width greater than five (5).

² Only required if slag is specified.

3 Coarse aggregate may only be accepted from sources that have a 20-year service history for the same gradation to be supplied with no history of D-Cracking. Aggregates that do not have a 20-year record of service free from major repairs (less than 5% of slabs replaced) in similar conditions without D-

cracking shall not be used unless the material currently being produced has a durability factor greater than or equal to 95 per ASTM C666. The Contractor shall submit a current certification and test results to verify the aggregate acceptability. Test results will only be accepted from a State Department of Transportation (DOT) materials laboratory or an accredited laboratory. Certification and test results which are not dated or which are over one (1) year old or which are for different gradations will not be accepted.

The amount of deleterious material in the coarse aggregate shall not exceed the following limits:

Deleterious material	ASTM	Percentage by Mass
Clay Lumps and friable particles	ASTM C142	1.0
Material finer than No. 200 sieve (75 µm)	ASTM C117	1.0 ¹
Lightweight particles	ASTM C123 using a medium with a density of Sp. Gr. of 2.0	0.5
Chert ² (less than 2.40 Sp Gr.)	ASTM C123 using a medium with a density of Sp. Gr. of 2.40)	0.13

Limits for Deleterious Substances in Coarse Aggregate

¹ The limit for material finer than 75-μm is allowed to be increased to 1.5% for crushed aggregates consisting of dust of fracture that is essentially free from clay or shale. Test results supporting acceptance of increasing limit to 1.5% with statement indicating material is dust of fracture must be submitted with Concrete mix. Acceptable techniques to characterizing these fines include methylene blue adsorption or X-ray diffraction analysis. The total of all deleterious materials increases up to 3.5%.

² Chert and aggregates with less than 2.4 specific gravity.

 3 The limit for chert may be limited to 0.1 percent by mass in areas subject to severe freeze and thaw.

d. Combined aggregate gradation. This specification is targeted for a combined aggregate gradation developed following the guidance presented in United States Air Force Engineering Technical Letter (ETL) 97-5: Proportioning Concrete Mixtures with Graded Aggregates for Rigid Airfield Pavements. Base the aggregate grading upon a combination of all the aggregates (coarse and fine) to be used for the mixture proportioning. Three aggregate sizes may be required to achieve an optimized combined gradation that will produce a workable concrete mixture for its intended use. Use aggregate gradations that produce concrete mixtures with well-graded or optimized aggregate combinations. The Contractor shall submit complete mixture information necessary to calculate the volumetric components of the mixture. The combined aggregate grading shall meet the following requirements:

a. (1) The materials selected and the proportions used shall be such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in paragraph 501-2.1d(4) below, the point thus determined shall fall within the parallelogram described therein.

- **b.** (2) The CF shall be determined from the following equation:
 - CF = (cumulative percent retained on the 3/8 in. (9.5 mm) sieve)(100) / (cumulative percent retained on the No. 8 (2.36 mm) sieve)

c. (3) The WF is defined as the percent passing the No. 8 (2.36 mm) sieve based on the combined gradation. However, WF shall be adjusted, upwards only, by 2.5 percentage points for each 94

pounds (42 kg) of cementitious material per cubic meter yard greater than 564 pounds per cubic yard (335 kg per cubic meter).

d. (4) A diagram shall be plotted using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram a parallelogram shall be plotted with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, the grading of each size of aggregate used and the proportions selected shall be changed as necessary. The point determined by the plotting of the CF and WF may be adjusted during production ± 3 WF and ± 5 CF. Adjustments to gradation may not take the point outside of the parallelogram.

e. Contractors combined aggregate gradation. The Contractor shall submit their combined aggregate gradation using the following format:

Sieve Size	Contractor's Concrete mix Gradation	
	(Percent passing by weight)	
2 inch (50 mm)	*	
1-1/2 inch (37.5 mm)	*	
1 inch (25.0 mm)	*	
3/4 inch (19.0 mm)	*	
1/2 inch (12.5 mm)	*	
3/8 inch (9.5 mm)	*	
No. 4 (4.75 mm)	*	
No. 8 (2.36 mm)	*	
No. 16 (1.18 mm)	*	
No. 30 (600 µm)	*	
No. 50 (300 µm)	*	
No. 100 (150 µm)	*	

Contractor's Combined Aggregate Gradation

501-2.2 Cement. Cement shall conform to the requirements of ASTM C150 - Type II.

If cement becomes partially set or contains lumps of caked cement, it shall be rejected. Cement salvaged from discarded or used bags shall not be used. Contractor shall supply Blaine Fineness values in accordance with ASTM C204 of cement used during preparation of mix design. Additionally, Blaine Fineness values shall be supplied at a minimum of once per month during PCC production. In no case shall Blaine Fineness values during production be less than that used during the preparation of the mix design.

501-2.3 Cementitious materials.

a. Fly ash. Fly ash shall meet the requirements of ASTM C618, with the exception of loss of ignition, where the maximum shall be less than 6%. Fly ash shall have a Calcium Oxide (CaO) content of less than 15% and a total alkali content less than 3% per ASTM C311. The Contractor shall furnish the previous three most recent, consecutive ASTM C618 reports for each source of fly ash proposed in the concrete mix,

and shall furnish each additional report as they become available during the project. The reports can be used for acceptance or the material may be tested independently by the Construction Manager.

b. Slag cement (ground granulated blast furnace (GGBF)). Slag cement shall conform to ASTM C989, Grade 100 or Grade 120. Slag cement shall be used only at a rate between 25% and 55% of the total cementitious material by mass.

c. Raw or calcined natural pozzolan. Natural pozzolan shall be raw or calcined and conform to ASTM C618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 6%. Class N pozzolan for use in mitigating Alkali-Silica Reactivity shall have a total available alkali content less than 3%.

d. Ultrafine fly ash and ultrafine pozzolan. UltraFine Fly Ash (UFFA) and UltraFine Pozzolan (UFP) shall conform to ASTM C618, Class F or N, and the following additional requirements:

(1) The strength activity index at 28 days of age shall be at least 95% of the control specimens.

(2) The average particle size shall not exceed 6 microns.

501-2.4 Joint seal. The joint seal for the joints in the concrete pavement shall meet the requirements of Item P-604 and shall be of the type specified in the plans.

<u>501-2.5 ISOLATION JOINT FILLER.</u> Premolded joint filler for isolation joints shall conform to the requirements of ASTM D1751 or ASTM D1752 and shall be where shown on the plans. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint, unless otherwise specified by the Construction Manager. When the use of more than one piece is required for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means satisfactory to the construction manager.

501-2.6 Steel reinforcement. Reinforcing shall consist of Grade 60 Deformed bars conforming to the requirements of ASTM A615 or welded wire reinforcement conforming to the requirements of ASTM A1064. Welded Wire fabric shall be furnished in flat sheets only.

501-2.7 Dowel and tie bars. Dowel bars shall be plain steel bars conforming to ASTM A615 and shall be free from burring or other deformation restricting slippage in the concrete.

a. Dowel Bars. Before delivery to the construction site each dowel bar shall be epoxy coated per ASTM A1078, Type 1, with a coating thickness after curing greater than 10 mils. Patched ends are not required for Type 1 coated dowels. The dowels shall be coated with a bond-breaker recommended by the manufacturer. Dowel sleeves or inserts are not permitted. Grout retention rings shall be fully circular metal or plastic devices capable of supporting the dowel until the grout hardens.

b. Tie Bars. Tie bars shall be deformed steel bars and conform to the requirements of ASTM A615. Tie bars designated as Grade 60 in ASTM A615 or ASTM A706 shall be used for construction requiring bent bars.

501-2.8 Water. Water used in mixing or curing shall be potable. If water is taken from other sources considered non-potable, it shall meet the requirements of ASTM C1602.

501-2.9 Material for curing concrete. Curing materials shall conform to the following specifications:

a. Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C309, Type 2, Class B.

501-2.10 Admixtures. Admixtures shall conform to the following specifications:

a. Air-entraining admixtures. Air-entraining admixtures shall meet the requirements of ASTM C260 and shall consistently entrain the air content in the specified ranges under field conditions. The air-entraining agent and any water reducer admixture shall be compatible.

b. Water-reducing admixtures. Water-reducing admixture shall meet the requirements of ASTM C494, Type A, B, or D.

c. Other admixtures. The use of set retarding and set-accelerating admixtures shall be approved by the Construction Manager prior to developing the concrete mix. Retarding admixtures shall meet the requirements of ASTM C494, Type A, B, or D and set-accelerating admixtures shall meet the requirements of ASTM C494, Type C. Calcium chloride and admixtures containing calcium chloride shall not be used.

d. Lithium Nitrate. The lithium admixture shall be a nominal 30% aqueous solution of Lithium Nitrate, with a density of 10 pounds/gallon (1.2 kg/L), and shall have the approximate chemical form as shown below:

Lithium Admixture

Constituent	Limit (Percent by Mass)
LiNO3 (Lithium Nitrate)	30 ±0.5
SO4 (Sulfate Ion)	0.1 (max)
Cl (Chloride Ion)	0.2 (max)
Na (Sodium Ion)	0.1 (max)
K (Potassium Ion)	0.1 (max)

The lithium nitrate admixture dispensing and mixing operations shall be verified and certified by the lithium manufacturer's representative.

501-2.11 Epoxy resin. All epoxy-resin materials shall be two-component materials conforming to the requirements of ASTM C881, Class as appropriate for each application temperature to be encountered, except that in addition, the materials shall meet the following requirements:

a. Material for use for embedding dowels and anchor bolts shall be Type IV, Grade 3.

c. Material for use for injecting cracks shall be Type IV, Grade 1.

501-2.12 Bond breaker. Prior to the placement of concrete forms or concrete pavement the Contractor shall apply a whitewash to the underlying ATPB surface consisting of a lime slurry. Lime slurry material shall consist of potable water and 30% hydrated lime by weight.

CONCRETE MIX

501-3.1. General. No concrete shall be placed until an acceptable concrete mix has been submitted to the Construction Manager for review and the Construction Manager has taken appropriate action. The Construction Manager's review shall not relieve the Contractor of the responsibility to select and proportion the materials to comply with this section.

501-3.2 Concrete mix laboratory. The laboratory used to develop the concrete mix shall be accredited in accordance with ASTM C1077. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for developing the concrete mix must be included in the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Construction Manager prior to start of construction.

501-3.3 Concrete mix proportions. Develop the mix using the procedures contained in Portland Cement Association (PCA) publication, "Design and Control of Concrete Mixtures." Concrete shall be proportioned to achieve a 28-day flexural strength that meets or exceeds the acceptance criteria contained in paragraph 501-6.6 for a flexural strength of 650 psi per ASTM C78.

The minimum cementitious material shall be adequate to ensure a workable, durable mix. The minimum cementitious material (cement plus fly ash, or slag cement) shall be 517 pounds per cubic yard (310 kg per cubic meter). The ratio of water to cementitious material, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates shall be less than 0.45 by weight.

Flexural strength test specimens shall be prepared in accordance with ASTM C192 and tested in accordance with ASTM C78. The mix determined shall be workable concrete having a maximum allowable slump between one and two inches as determined by ASTM C143. For slip-form concrete, the slump shall be between 1/2 inch and 1-1/2 inch. At the start of the project, the Contractor shall determine a maximum allowable slump for slip-form pavement which will produce in-place pavement to control the edge slump. The selected slump shall be applicable to both pilot and fill-in lanes.

The results of the concrete mix shall include a statement giving the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic yard (meter) basis. Aggregate quantities shall be based on the mass in a saturated surface dry condition.

If a change in source(s) is made, or admixtures added or deleted from the mix, a new concrete mix must be submitted to the Construction Manager for approval.

The Construction Manager may request samples at any time for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

501-3.4 Concrete mix submittals. The concrete mix shall be submitted to the Construction Manager at least 14 days prior to the start of operations. The submitted concrete mix shall not be more than 180 days old and must use the materials to be used for production for the project. Production shall not begin until the concrete mix is approved in writing by the Engineer.

Each of the submitted concrete mixes (i.e, slip form, side form machine finish and side form hand finish) shall be stamped or sealed by the responsible Professional Engineer of the laboratory and shall include the following items and quantities as a minimum:

- Certified material test reports for aggregate in accordance with paragraph 501-2.1. Certified reports must include all tests required; reporting each test, test method, test result, and requirement specified (criteria).
- Combined aggregate gradations and analysis; and including plots of the fine aggregate fineness modulus.
- Reactivity Test Results.
- Coarse aggregate quality test results, including deleterious materials.
- Fine aggregate quality test results, including deleterious materials.
- Mill certificates for cement and supplemental cementitious materials.
- Certified test results for all admixtures, including Lithium Nitrate if applicable.
- Specified flexural strength, slump, and air content.
- Recommended proportions/volumes for proposed mixture and trial water-cementitious materials ratio, including actual slump and air content.
- Flexural and compressive strength summaries and plots, including all individual beam and cylinder breaks.
- Correlation ratios for acceptance testing and Contractor QC testing, when applicable.
- Historical record of test results documenting production standard deviation, when applicable.

501-3.5 Cementitious materials.

a. Fly ash. When fly ash is used as a partial replacement for cement, the replacement rate shall be determined from laboratory trial mixes, and shall be between 20 and 30% by weight of the total cementitious material. If fly ash is used in conjunction with slag cement the maximum replacement rate shall not exceed 10% by weight of total cementitious material.

b. Slag cement (ground granulated blast furnace (GGBF)). Slag cement may be used. The slag cement, or slag cement plus fly ash if both are used, may constitute between 25 to 55% of the total cementitious material by weight.

c. Raw or calcined natural pozzolan. Natural pozzolan may be used in the concrete mix. When pozzolan is used as a partial replacement for cement, the replacement rate shall be determined from laboratory trial mixes, and shall be between 20 and 30% by weight of the total cementitious material. If pozzolan is used in conjunction with slag cement the maximum replacement rate shall not exceed 10% by weight of total cementitious material.

d. Ultrafine fly ash (UFFA) and ultrafine pozzolan (UFP). UFFA and UFP may be used in the concrete mix with the Engineer's approval. When UFFA and UFP is used as a partial replacement for cement, the replacement rate shall be determined from laboratory trial mixes, and shall be between 7% and 16% by weight of the total cementitious material.

501-3.6 Admixtures.

a. Air-entraining admixtures. Air-entraining admixture are to be added in such a manner that will ensure uniform distribution of the agent throughout the batch. The air content of freshly mixed air-entrained concrete shall be based upon trial mixes with the materials to be used in the work adjusted to produce concrete of the required plasticity and workability. The percentage of air in the mix shall be 5%. Air content shall be determined by testing in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag and other highly porous coarse aggregate.

b. Water-reducing admixtures. Water-reducing admixtures shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Tests shall be conducted with the materials to be used in the work, in accordance with ASTM C494.

c. Other admixtures. Set controlling, and other approved admixtures shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Tests shall be conducted with the materials to be used in the work, in accordance with ASTM C494.

d. Lithium nitrate. Lithium nitrate shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements in accordance with paragraph 501-2.10d.

CONSTRUCTION METHODS

501-4.1 Control strip. The control strip(s) shall be to the next planned joint after the initial 250 feet (75 m) of each type of pavement construction (slip-form pilot lane, slip-form fill-in lane, or fixed form). The Contractor shall demonstrate, in the presence of the Construction Manager, that the materials, concrete mix, equipment, construction processes, and quality control processes meet the requirements of the specifications. The concrete mixture shall be extruded from the paver meeting the edge slump tolerance and with little or no finishing. Pilot, fill-in, and fixed-form control strips will be accepted separately. Minor adjustments to the mix design may be required to place an acceptable control strip. The production mix will be the adjusted mix design used to place the acceptable control strip. Upon acceptance of the control strip by the Construction Manager, the Contractor must use the same equipment, materials, and construction methods for the remainder of concrete paving. Any adjustments to processes or materials must be approved in advance by the Construction Manager. The acceptable control strip shall be paid for in accordance with paragraph 501-6.6.

501-4.2 Equipment. The Contractor is responsible for the proper operation and maintenance of all equipment necessary for handling materials and performing all parts of the work to meet this specification.

a. Plant and equipment. The plant and mixing equipment shall conform to the requirements of ASTM C94 and/or ASTM C685. Each truck mixer shall have attached in a prominent place a manufacturer's nameplate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades. The truck mixers shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades. The pickup and throwover blades shall be replaced when they have worn down 3/4 inch (19 mm) or more. The Contractor shall have a copy of the manufacturer's design on hand showing dimensions and arrangement of blades in reference to original height and depth.

Equipment for transferring and spreading concrete from the transporting equipment to the paving lane in front of the finishing equipment shall be provided. The equipment shall be specially manufactured, selfpropelled transfer equipment which will accept the concrete outside the paving lane and will spread it evenly across the paving lane in front of the paver and strike off the surface evenly to a depth which permits the paver to operate efficiently.

b. Finishing equipment.

(1) Slip-form. The standard method of constructing concrete pavements shall be with an approved slip-form paving equipment designed and operated to spread, consolidate, screed, and finish the freshly placed concrete in one complete pass of the machine so that the end result is a dense and homogeneous pavement which is achieved with a minimum of hand finishing. The paver-finisher shall be a heavy duty, self-propelled machine designed specifically for paving and finishing high quality concrete pavements.

(2) Fixed-form. On projects requiring less than 10,000 cubic yards (7650 cubic meters) of concrete pavement or irregular areas at locations inaccessible to slip-form paving equipment, concrete pavement may be placed with equipment specifically designed for placement and finishing using stationary side forms. Methods and equipment shall be reviewed and accepted by the Construction Manager. Hand screeding and float finishing may only be used on small irregular areas as allowed by the Construction Manager.

c. Vibrators. Vibrator shall be the internal type. The rate of vibration of each vibrating unit shall be sufficient to consolidate the pavement without segregation or voids. The number, spacing, and frequency shall be as necessary to provide a dense and homogeneous pavement and meet the recommendations of American Concrete Institute (ACI) 309R, Guide for Consolidation of Concrete. Adequate power to operate all vibrators shall be available on the paver. The vibrators shall be automatically controlled so that they shall be stopped as forward motion ceases. The Contractor shall provide an electronic or mechanical means to monitor vibrator status. The checks on vibrator status shall occur a minimum of two times per day or when requested by the Construction Manager.

Hand held vibrators may only be used in irregular areas and shall meet the recommendations of ACI 309R, Guide for Consolidation of Concrete.

d. Concrete saws. The Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions. The Contractor shall provide at least one standby saw in good working order and a supply of saw blades at the site of the work at all times during sawing operations.

e. Fixed forms. Straight side fixed forms shall be made of steel and shall be furnished in sections not less than 10 feet (3 m) in length. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built-up forms shall not be used, except as approved by the Engineer. The top face of the form shall not vary from a true plane more than 1/8 inch (3 mm) in 10 feet (3 m), and the upstanding leg shall not vary more than 1/4 inch (6 mm). The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when approved by the Engineer. The forms shall extend the full depth of the pavement section.

501-4.3 Form setting. Forms shall be set to line and grade as shown on the plans, sufficiently in advance of the concrete placement, to ensure continuous paving operation. Forms shall be set to withstand, without

visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the concrete placement.

501-4.4 Base and surface preparation prior to placement. Any damage to the prepared base, subbase, and subgrade shall be corrected full depth by the Contractor prior to concrete placement. The underlying surface shall be entirely free of frost when concrete is placed. The prepared grade shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete. Bond breaker shall be applied in accordance with 501-2.12.

501-4.5 Handling, measuring, and batching material. Aggregate stockpiles shall be constructed and managed in such a manner that prevents segregation and intermixing of deleterious materials. Aggregates from different sources shall be stockpiled, weighed and batched separately at the concrete batch plant. Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Store and maintain all aggregates at a uniform moisture content prior to use. A continuous supply of materials shall be provided to the work to ensure continuous placement.

501-4.6 Mixing concrete. The concrete may be mixed at the work site, in a central mix plant or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials are placed into the drum until the drum is emptied into the truck. All concrete shall be mixed and delivered to the site in accordance with the requirements of ASTM C94 or ASTM C685.

Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators, or nonagitating trucks. The elapsed time from the addition of cementitious material to the mix until the concrete is discharged from the truck should not exceed 30 minutes when the concrete is hauled in non-agitating trucks, nor 90 minutes when the concrete is hauled in truck mixers or truck agitators. In no case shall the temperature of the concrete when placed exceed 90°F (32°C). Retempering concrete by adding water or by other means will not be permitted. With transit mixers additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements provided the addition of water is performed within 45 minutes after the initial mixing operations and provided the water/cementitious ratio specified is not exceeded.

501-4.7 Weather limitations of mixing and placing. No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

a. Cold weather. Unless authorized in writing by the Construction Manager, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 40° F (4° C) and shall not be resumed until an ascending air temperature in the shade and away from artificial heat reaches 35° F (2° C).

The aggregate shall be free of ice, snow, and frozen lumps before entering the mixer. The temperature of the mixed concrete shall not be less than 50° F (10° C) at the time of placement. Concrete shall not be placed on frozen material nor shall frozen aggregates be used in the concrete.

When concreting is authorized during cold weather, water and/or the aggregates may be heated to not more than $150^{\circ}F$ (66°C). The apparatus used shall heat the mass uniformly and shall be arranged to preclude the possible occurrence of overheated areas which might be detrimental to the materials.

Curing during cold weather shall be in accordance with paragraph 501-4.13d.

b. Hot weather. During periods of hot weather when the maximum daily air temperature exceeds 85°F (30°C), the following precautions shall be taken.

The forms and/or the underlying surface shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 90°F (32°C). The aggregates and/or mixing water shall be cooled as necessary to maintain the concrete temperature at or not more than the specified maximum.

The concrete placement shall be protected from exceeding an evaporation rate of 0.2 psf (0.98 kg/m² per hour) per hour. When conditions are such that problems with plastic cracking can be expected, and particularly if any plastic cracking begins to occur, the Contractor shall immediately take such additional measures as necessary to protect the concrete surface. If the Contractor's measures are not effective in preventing plastic cracking, paving operations shall be immediately stopped.

Curing during hot weather shall be in accordance with paragraph 501-4.13e.

c. Temperature management program. Prior to the start of paving operation for each day of paving, the Contractor shall provide the Construction Manager with a Temperature Management Program for the concrete to be placed to assure that uncontrolled cracking is avoided. (Federal Highway Administration HIPERPAV 3 is one example of a temperature management program.) As a minimum, the program shall address the following items:

(1) Anticipated tensile strains in the fresh concrete as related to heating and cooling of the concrete material.

(2) Anticipated weather conditions such as ambient temperatures, wind velocity, and relative humidity; and anticipated evaporation rate using Figure 19-9, PCA, Design and Control of Concrete Mixtures.

(3) Anticipated timing of initial sawing of joint.

(4) Anticipated number and type of saws to be used.

d. **Rain.** The Contractor shall have available materials for the protection of the concrete during inclement weather. Such protective materials shall consist of rolled polyethylene sheeting at least 4 mils (0.1 mm) thick of sufficient length and width to cover the plastic concrete slab and any edges. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the plastic concrete surface. When rain appears imminent, all paving operations shall stop and all available personnel shall begin covering the surface of the unhardened concrete with the protective covering.

501-4.8 Concrete placement. At any point in concrete conveyance, the free vertical drop of the concrete from one point to another or to the underlying surface shall not exceed 3 feet (1 m). The finished concrete product must be dense and homogeneous, without segregation and conforming to the standards in this specification. Backhoes and grading equipment shall not be used to distribute the concrete in front of the paver. Front end loaders will not be used. All concrete shall be consolidated without voids or segregation, including under and around all load-transfer devices, joint assembly units, and other features embedded in the pavement. Hauling equipment or other mechanical equipment can be permitted on adjoining previously constructed pavement when the concrete strength reaches a flexural strength of 550 psi (3.8 MPa), based on the average of four field cured specimens per 2,000 cubic yards (1,530 cubic meters) of concrete placed. The Contractor must determine that the above minimum strengths are adequate to protection the pavement from overloads due to the construction equipment proposed for the project.

The Contractor shall have available materials for the protection of the concrete during cold, hot and/or inclement weather in accordance with paragraph 501-4.7.

a. Slip-form construction. The concrete shall be distributed uniformly into final position by a selfpropelled slip-form paver without delay. The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose. The paver shall vibrate the concrete for the full width and depth of the strip of pavement being placed and the vibration shall be adequate to provide a consistency of concrete that will stand normal to the surface with sharp well-defined edges. The sliding forms shall be rigidly held together laterally to prevent spreading of the forms. The plastic concrete shall be effectively consolidated by internal vibration with transverse vibrating units for the full width of the pavement and/or a series of equally placed longitudinal vibrating units. The space from the outer edge of the pavement to longitudinal unit shall not exceed 9 inches (23 cm) for slipform and at the end of the dowels for the fill-in lanes. The spacing of internal units shall be uniform and shall not exceed 18 inches (0.5 m).

The term internal vibration means vibrating units located within the specified thickness of pavement section.

The rate of vibration of each vibrating unit shall be sufficient to consolidate the pavement without, segregation, voids, or vibrator trails and the amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete along the entire length of the vibrating unit and for a distance of at least one foot (30 cm). The frequency of vibration or amplitude should be adjusted proportionately with the rate of travel to result in a uniform density and air content. The paving machine shall be equipped with a tachometer or other suitable device for measuring and indicating the actual frequency of vibrations.

The concrete shall be held at a uniform consistency. The slip-form paver shall be operated with as nearly a continuous forward movement as possible and all operations of mixing, delivering, and spreading concrete shall be coordinated to provide uniform progress with stopping and starting of the paver held to a minimum. If for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

When concrete is being placed adjacent to an existing pavement, that part of the equipment which is supported on the existing pavement shall be equipped with protective pads on crawler tracks or rubber-tired wheels on which the bearing surface is offset to run a sufficient distance from the edge of the pavement to avoid breaking the pavement edge.

Not more than 15% of the total free edge of each 500-foot (150 m) segment of pavement, or fraction thereof, shall have an edge slump exceeding 1/4 inch (6 mm), and none of the free edge of the pavement shall have an edge slump exceeding 3/8 inch (9 mm). (The total free edge of 500 feet (150 m) of pavement will be considered the cumulative total linear measurement of pavement edge originally constructed as nonadjacent to any existing pavement; that is, 500 feet (150 m) of paving lane originally constructed as a separate lane will have 1,000 feet (300 m) of free edge, 500 feet (150 m) of fill-in lane will have no free edge, etc.). The area affected by the downward movement of the concrete along the pavement edge shall be limited to not more than 18 inches (0.5 m) from the edge.

When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive edge slump will be removed the full width of the slip form lane and replaced at the expense of the Contractor as directed by the Construction Manager.

b. Fixed-form construction. Forms shall be drilled in advance of being placed to line and grade to accommodate tie bars / dowel bars where these are specified.

Immediately in advance of placing concrete and after all subbase operations are completed, side forms shall be trued and maintained to the required line and grade for a distance sufficient to prevent delay in placing.

Side forms shall remain in place at least 12 hours after the concrete has been placed, and in all cases until the edge of the pavement no longer requires the protection of the forms. <u>Curing compound shall be applied to the concrete immediately after the forms have been removed</u>.

Side forms shall be thoroughly cleaned and coated with a release agent each time they are used and before concrete is placed against them.

Concrete shall be spread, screed, shaped and consolidated by one or more self-propelled machines. These machines shall uniformly distribute and consolidate concrete without segregation so that the completed pavement will conform to the required cross-section with a minimum of handwork.

The number and capacity of machines furnished shall be adequate to perform the work required at a rate equal to that of concrete delivery. The equipment must be specifically designed for placement and finishing using stationary side forms. Methods and equipment shall be reviewed and accepted by the Construction Manager.

Concrete for the full paving width shall be effectively consolidated by internal vibrators. The rate of vibration of each vibrating unit shall be sufficient to consolidate the pavement without segregation, voids, or leaving vibrator trails.

Power to vibrators shall be connected so that vibration ceases when forward or backward motion of the machine is stopped.

c. Consolidation. Concrete shall be consolidated with the specified type of lane-spanning, gangmounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand-operated vibrators. The vibrators shall be inserted into the concrete to a depth that will provide the best full-depth consolidation but not closer to the underlying material than 2 inches (50 mm). Vibrators shall not be used to transport or spread the concrete. For each paving train, at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators shall be maintained at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) or over-consolidation (vibrator trails, segregation, or any other evidence) shall require the immediate stopping of the paving operation and adjustment of the equipment or procedures as approved by the Construction Manager.

If a lack of consolidation of the hardened concrete is suspected by the Construction Manager, referee testing may be required. Referee testing of hardened concrete will be performed by the Contractor by cutting cores from the finished pavement after a minimum of 24 hours curing. The Construction Manager shall visually examine the cores for evidence of lack of consolidation. Density determinations will be made by the Construction Manager based on the water content of the core as taken. ASTM C642 shall be used for the determination of core density in the saturated-surface dry condition. When required, referee cores will be taken at the minimum rate of one for each 500 cubic yards (382 m²) of pavement, or fraction. The Contractor shall be responsible for all referee testing cost if they fail to meet the required density.

The average density of the cores shall be at least 97% of the original concrete mix density, with no cores having a density of less than 96% of the original concrete mix density. Failure to meet the referee tests will be considered evidence that the minimum requirements for vibration are inadequate for the job

conditions. Additional vibrating units or other means of increasing the effect of vibration shall be employed so that the density of the hardened concrete conforms to the above requirements.

501-4.9 Strike-off of concrete placement of reinforcement. Following the placing of the concrete, it shall be struck off to conform to the cross-section shown on the plans and to an elevation that when the concrete is properly consolidated and finished, the surface of the pavement shall be at the elevation shown on the plans. When reinforced concrete pavement is placed in two layers, the bottom layer shall be struck off to such length and depth that the sheet of reinforcing steel fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck off, and screed. If any portion of the bottom layer of concrete has been placed more than 30 minutes without being covered with the top layer or if initial set has taken place, it shall be removed and replaced with freshly mixed concrete at the Contractor's expense. When reinforced concrete is placed in one layer, the reinforcement may be positioned in advance of concrete placement or it may be placed in plastic concrete by mechanical or vibratory means after spreading.

Reinforcing steel, at the time concrete is placed, shall be free of mud, oil, or other organic matter that may adversely affect or reduce bond. Reinforcing steel with rust, mill scale or a combination of both will be considered satisfactory, provided the minimum dimensions, weight, and tensile properties of a hand wirebrushed test specimen are not less than the applicable ASTM specification requirements.

501-4.10 Joints. Joints shall be constructed as shown on the plans and in accordance with these requirements. All joints shall be constructed with their faces perpendicular to the surface of the pavement and finished or edged as shown on the plans. Joints shall not vary more than 1/2-inch (12 mm) from their designated position and shall be true to line with not more than 1/4-inch (6 mm) variation in 10 feet (3 m). The surface across the joints shall be tested with a 12-foot (3 m) straightedge as the joints are finished and any irregularities in excess of 1/4 inch (6 mm) shall be corrected before the concrete has hardened. All joints shall be so prepared, finished, or cut to provide a groove of uniform width and depth as shown on the plans.

a. Construction. Longitudinal construction joints shall be slip-formed or formed against side forms as shown in the plans.

Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for more than 30 minutes or it appears that the concrete will obtain its initial set before fresh concrete arrives. The installation of the joint shall be located at a planned contraction or expansion joint. If placing of the concrete is stopped, the Contractor shall remove the excess concrete back to the previous planned joint.

b. Contraction. Contraction joints shall be installed at the locations and spacing as shown on the plans. Contraction joints shall be installed to the dimensions required by forming a groove or cleft in the top of the slab while the concrete is still plastic or by sawing a groove into the concrete surface after the concrete has hardened. When the groove is formed in plastic concrete the sides of the grooves shall be finished even and smooth with an edging tool. If an insert material is used, the installation and edge finish shall be according to the manufacturer's instructions. The groove shall be finished or cut clean so that spalling will be avoided at intersections with other joints. Grooving or sawing shall produce a slot at least 1/8 inch (3 mm) wide and to the depth shown on the plans.

c. Isolation (expansion). Isolation joints shall be installed as shown on the plans. The premolded filler of the thickness as shown on the plans, shall extend for the full depth and width of the slab at the joint. The filler shall be fastened uniformly along the hardened joint face with no buckling or debris between the filler

and the concrete interface, including a temporary filler for the sealant reservoir at the top of the slab. The edges of the joint shall be finished and tooled while the concrete is still plastic

d. Dowels and Tie Bars for Joints

(1) Tie bars. Tie bars shall consist of deformed bars installed in joints as shown on the plans. Tie bars shall be placed at right angles to the centerline of the concrete slab and shall be spaced at intervals shown on the plans. They shall be held in position parallel to the pavement surface and in the middle of the slab depth and within the tolerances in paragraph 501-4.10(f.). When tie bars extend into an unpaved lane, they may be bent against the form at longitudinal construction joints, unless threaded bolt or other assembled tie bars are specified. Tie bars shall not be painted, greased, or enclosed in sleeves. When slip-form operations call for tie bars, two-piece hook bolts can be installed.

(2) Dowel bars. Dowel bars shall be placed across joints in the proper horizontal and vertical alignment as shown on the plans. The dowels shall be coated with a bond-breaker or other lubricant recommended by the manufacturer and approved by the Engineer. Dowels bars at longitudinal construction joints shall be bonded in drilled holes.

(3) Placing dowels and tie bars. Horizontal spacing of dowels shall be within a tolerance of $\pm 3/4$ inch (19 mm). The vertical location on the face of the slab shall be within a tolerance of $\pm 1/2$ inch (12 mm). The method used to install dowels shall ensure that the horizontal and vertical alignment will not be greater than 1/4 inch per feet (6 mm per 0.3 m), except for those across the crown or other grade change joints. Dowels across crowns and other joints at grade changes shall be measured to a level surface. Horizontal alignment shall be checked perpendicular to the joint edge. The portion of each dowel intended to move within the concrete or expansion cap shall be wiped clean and coated with a thin, even film of lubricating oil or light grease before the concrete is placed. Dowels shall be installed as specified in the following subparagraphs.

Dowels and tie bars shall not be placed closer than 0.6 times the dowel bar or tie bar length to the planned joint line. If the last regularly spaced longitudinal dowel and/or tie bar is closer than that dimension, it shall be moved away from the joint to a location 0.6 times the dowel bar and/or tie bar length, but not closer than 6 inches (150 mm) to its nearest neighbor.

(a) Contraction joints. Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane shall be held securely in place by means of rigid metal frames or basket assemblies of an approved type. The basket assemblies shall be held securely in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires.

Insertion of dowels in plastic concrete will not be allowed.

(b) Construction joints. Install dowels and tie bars by the cast-in- place or the drill-anddowel method. Installation by removing and replacing in preformed holes will not be permitted. Dowels and tie bars shall be prepared and placed across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms.

(c) Joints in hardened concrete. Install dowels in hardened concrete by bonding the dowels into holes drilled into the concrete. The concrete shall have cured for seven (7) days or reached a minimum flexural strength of 450 psi (3.1 MPa) before drilling begins. Holes 1/8 inch (3 mm) greater in diameter than the dowels shall be drilled into the hardened concrete using rotary-core drills. Rotary-percussion drills may be used, provided that excessive spalling does not occur. Spalling beyond the limits of the grout retention ring will require modification of the equipment and operation. Depth of dowel hole shall be within a tolerance of $\pm 1/2$ inch (12 mm) of the dimension shown on the drawings. On completion of the drilling operation, the dowel hole shall be blown out with oil-free, compressed air. Dowels shall be

bonded in the drilled holes using epoxy resin. Epoxy resin shall be injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel will not be permitted. The dowels shall be held in alignment at the collar of the hole by means of a suitable metal or plastic grout retention ring fitted around the dowel.

(d) Sawing of joints. Sawing shall commence, without regard to day or night, as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing and before uncontrolled shrinkage cracking of the pavement occurs and shall continue without interruption until all joints have been sawn. All slurry and debris produced in the sawing of joints shall be removed by vacuuming and washing. Curing compound or system shall be reapplied in the initial saw-cut and maintained for the remaining cure period.

Joints shall be cut in locations as shown on the plans. The initial joint cut shall be a minimum 1/8 inch (3 mm) wide and to the depth shown on the plans. Prior to placement of joint sealant or seals, the top of the joint shall be widened by sawing as shown on the plans.

501-4.11 Finishing. Finishing operations shall be a continuing part of placing operations starting immediately behind the strike-off of the paver. Initial finishing shall be provided by the transverse screed or extrusion plate. The sequence of operations shall be transverse finishing, longitudinal machine floating if used, straightedge finishing, edging of joints, and then texturing. Finishing shall be by the machine method. The hand method shall be used only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Supplemental hand finishing for machine finished pavement shall be kept to an absolute minimum. Any machine finishing operation which requires appreciable hand finishing, other than a moderate amount of straightedge finishing, shall be immediately stopped and proper adjustments made or the equipment replaced. Equipment, mixture, and/or procedures which produce more than 1/4 inch (6 mm) of mortar-rich surface shall be immediately modified as necessary to eliminate this condition or operations shall cease. Compensation shall be made for surging behind the screeds or extrusion plate and settlement during hardening and care shall be taken to ensure that paving and finishing machines are properly adjusted so that the finished surface of the concrete (not just the cutting edges of the screeds) will be at the required line and grade. Finishing equipment and tools shall be maintained clean and in an approved condition. At no time shall water be added to the surface of the slab with the finishing equipment or tools, or in any other way. Fog (mist) sprays or other surface applied finishing aids specified to prevent plastic shrinkage cracking, approved by the Engineer, may be used in accordance with the manufacturers requirements.

a. Machine finishing with slipform pavers. The slipform paver shall be operated so that only a very minimum of additional finishing work is required to produce pavement surfaces and edges meeting the specified tolerances. Any equipment or procedure that fails to meet these specified requirements shall immediately be replaced or modified as necessary. A self-propelled non-rotating pipe float may be used while the concrete is still plastic, to remove minor irregularities and score marks. Only one pass of the pipe float shall be allowed. Equipment, mixture, and/or procedures which produce more than 1/4 inch (6 mm) of mortar-rich surface shall be immediately modified as necessary to eliminate this condition or operations shall cease. Remove excessive slurry from the surface with a cutting straightedge and wipe off the edge. Any slurry which does run down the vertical edges shall be immediately removed by hand, using stiff brushes or scrapers. No slurry, concrete or concrete mortar shall be used to build up along the edges of the pavement to compensate for excessive edge slump, either while the concrete is plastic or after it hardens.

b. Machine finishing with fixed forms. The machine shall be designed to straddle the forms and shall be operated to screed and consolidate the concrete. Machines that cause displacement of the forms shall be replaced. The machine shall make only one pass over each area of pavement. If the equipment and

procedures do not produce a surface of uniform texture, true to grade, in one pass, the operation shall be immediately stopped and the equipment, mixture, and procedures adjusted as necessary.

c. Other types of finishing equipment. Clary screeds, other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd-shaped slabs, and near buildings or trench drains, subject to the Engineer's approval.

Bridge deck finishers shall have a minimum operating weight of 7500 pounds (3400 kg) and shall have a transversely operating carriage containing a knock-down auger and a minimum of two immersion vibrators. Vibrating screeds or pans shall be used only for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

d. Hand finishing. Hand finishing methods will not be permitted, except under the following conditions: (1) in the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade and (2) in areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical.

e. Straightedge testing and surface correction. After the pavement has been struck off and while the concrete is still plastic, it shall be tested for trueness with a 12-foot (3.7-m) finishing straightedge swung from handles capable of spanning at least one-half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the centerline and the whole area gone over from one side of the slab to the other, as necessary. Advancing shall be in successive stages of not more than one-half the length of the straightedge. Any excess water and laitance in excess of 1/8 inch (3 mm) thick shall be removed from the surface of the pavement and wasted. Any depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the smoothness requirements. Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and until the slab conforms to the required grade and cross-section. The use of long-handled wood floats shall be confined to a minimum; they may be used only in emergencies and in areas not accessible to finishing equipment.

501-4.12 Surface texture. The surface of the pavement shall be finished as designated below for all newly constructed concrete pavements. It is important that the texturing equipment not tear or unduly roughen the pavement surface during the operation. The texture shall be uniform in appearance and approximately 1/16 inch (2 mm) in depth. Any imperfections resulting from the texturing operation shall be corrected to the satisfaction of the Construction Manager.

a. Brush or broom finish. Shall be applied when the water sheen has practically disappeared. The equipment shall operate transversely across the pavement surface.

b. Burlap drag finish. Burlap, at least 15 ounces per square yard (555 grams per square meter), will typically produce acceptable texture. To obtain a textured surface, the transverse threads of the burlap shall be removed approximately one foot (30 cm) from the trailing edge. A heavy buildup of grout on the burlap threads produces the desired wide sweeping longitudinal striations on the pavement surface.

c. Artificial turf finish. Shall be applied by dragging the surface of the pavement in the direction of concrete placement with an approved full-width drag made with artificial turf. The leading transverse edge of the artificial turf drag will be securely fastened to a lightweight pole on a traveling bridge. At least 2 feet (60 cm) of the artificial turf shall be in contact with the concrete

surface during dragging operations. Approval of the artificial turf will be done only after it has been demonstrated by the Contractor to provide a satisfactory texture. One type that has provided satisfactory texture consists of 7,200 approximately 0.85-inch-long polyethylene turf blades per square foot.

501-4.13 Curing. Immediately after finishing operations are completed and bleed water is gone from the surface, all exposed surfaces of the newly placed concrete shall be cured for a 7-day cure period in accordance with one of the methods below. Failure to provide sufficient cover material of whatever kind the Contractor may elect to use, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 1/2 hour during the curing period.

When a two-saw-cut method is used to construct the contraction joint, the curing compound shall be applied to the saw-cut immediately after the initial cut has been made. The sealant reservoir shall not be sawed until after the curing period has been completed. When the one cut method is used to construct the contraction joint, the joint shall be cured with wet rope, wet rags, or wet blankets. The rags, ropes, or blankets shall be kept moist for the duration of the curing period.

a. Impervious membrane method. All exposed surfaces of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place. The curing compound shall not be applied during rainfall. Curing compound shall be applied by mechanical sprayers under pressure at the rate of two gallons (8 liters) to not more than 150 square feet (14 sq m). The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application, the compound shall be stirred continuously by mechanical means. Hand spraying of odd widths or shapes and concrete surfaces exposed by the removal of forms will be permitted. When hand spraying is approved by the Construction Manager, a double application rate shall be used to ensure coverage. Should the film become damaged from any cause, including sawing operations, within the required curing period, the damaged portions shall be repaired immediately with additional compound or other approved means. Upon removal of side forms, the sides of the exposed slabs shall be protected immediately to provide a curing treatment equal to that provided for the surface.

b. Concrete protection for cold weather. Maintain the concrete at a temperature of at least 50° F (10°C) for a period of 72 hours after placing and at a temperature above freezing for the remainder of the 7-day curing period. The Contractor shall be responsible for the quality and strength of the concrete placed during cold weather; and any concrete damaged shall be removed and replaced at the Contractor's expense.

501-4.14 Removing forms. Unless otherwise specified, forms shall not be removed from freshly placed concrete until it has hardened sufficiently to permit removal without chipping, spalling, or tearing. After the forms have been removed, the sides of the slab shall be cured in accordance with paragraph 501-4.13.

If honeycombed areas are evident when the forms are removed, materials, placement, and consolidation methods must be reviewed and appropriate adjustments made to assure adequate consolidation at the edges of future concrete placements. Honeycombed areas that extend into the slab less than approximately 1 inch (25 mm), shall be repaired with an approved grout, as directed by the Engineer. Honeycombed areas that extend into the slab greater than a depth of 1 inch (25 mm) shall be considered as defective work and shall be removed and replaced in accordance with paragraph 501-4.19.

501-4.15 Saw-cut grooving. As shown on the plans, grooved surfaces shall be provided on Runway pavement surface in accordance with the requirements of Item P-621.

501-4.16 Sealing joints. The joints in the pavement shall be sealed in accordance with Item P-605 as shown within the plans.

501-4.17 Protection of pavement. The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents until accepted by the Construction Manager. This shall include watchmen to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, crossovers, and protection of unsealed joints from intrusion of foreign material, etc. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the Contractor's expense.

Aggregates, rubble, or other similar construction materials shall not be placed on airfield pavements. Traffic shall be excluded from the new pavement by erecting and maintaining barricades and signs until the concrete is at least seven (7) days old, or for a longer period if directed by the Construction Manager.

In paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment will be permitted on the new pavement after the pavement has been cured for seven (7) days, the joints are protected, the concrete has attained a minimum field cured flexural strength of 450 psi (3100 kPa), and the slab edge is protected.

All new and existing pavement carrying construction traffic or equipment shall be kept clean and spillage of concrete and other materials shall be cleaned up immediately.

Damaged pavements shall be removed and replaced at the Contractor's expense. Slabs shall be removed to the full depth, width, and length of the slab.

501-4.18 Opening to construction traffic. The pavement shall not be opened to traffic until test specimens molded and cured in accordance with ASTM C31 have attained a flexural strength of 450 pounds per square inch (3100 kPa) when tested in accordance with ASTM C78. If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete was placed. Prior to opening the pavement to construction traffic, all joints shall either be sealed or protected from damage to the joint edge and intrusion of foreign materials into the joint. As a minimum, backer rod or tape may be used to protect the joints from foreign matter intrusion.

501-4.19 Repair, removal, or replacement of slabs. New pavement slabs that are broken or contain cracks or are otherwise defective or unacceptable as defined by acceptance criteria in paragraph 501-6.6 shall be removed and replaced or repaired, as directed by the Construction Manager, at the Contractor's expense. Spalls along joints shall be repaired as specified within Item P-607. Removal of partial slabs is not permitted. Removal and replacement shall be full depth, shall be full width of the slab, and the limit of removal shall be normal to the paving lane and to each original transverse joint. The Construction Manager will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be filled by the Contractor with a well consolidated concrete mixture bonded to the walls of the hole with a bonding agent, using approved procedures. Drilling of cores and refilling holes shall be at no expense to the Owner. Repair of cracks as described in this section shall not be allowed if in the opinion of the Construction Manager the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of cracks shall be allowed in any panel that demonstrates segregated aggregate with an absence of coarse aggregate in the upper 1/8 inch (3 mm) of the pavement surface.

a. Shrinkage cracks. Shrinkage cracks which do not exceed one-third of the pavement depth shall be cleaned and either high molecular weight methacrylate (HMWM) applied; or epoxy resin (Type IV, Grade 1) pressure injected using procedures recommended by the manufacturer and approved by the Engineer.

Sandblasting of the surface may be required following the application of HMWM to restore skid resistance. Care shall be taken to ensure that the crack is not widened during epoxy resin injection. All epoxy resin injection shall take place in the presence of the Construction Manager. Shrinkage cracks which exceed one-third the pavement depth shall be treated as full depth cracks in accordance with paragraphs 501-4.19b and 501-19c.

b. Slabs with cracks through interior areas. Interior area is defined as that area more than 6 inches (150 mm) from either adjacent original transverse joint. The full slab shall be removed and replaced at no cost to the Owner, when there are any full depth cracks, or cracks greater than one-third the pavement depth, that extend into the interior area.

c. Cracks close to and parallel to joints. All full-depth cracks within 6 inches (150 mm) either side of the joint and essentially parallel to the original joints, shall be treated as follows.

(1) Full depth cracks and original joint not cracked. The full-depth crack shall be treated as the new joint and the original joint filled with an epoxy resin.

i. Full-depth crack. The joint sealant reservoir for the crack shall be formed by sawing to a depth of 3/4 inches (19 mm), $\pm 1/16$ inch (2 mm), and to a width of 5/8 inch (16 mm), $\pm 1/8$ inch (3 mm). The crack shall be sawed with equipment specially designed to follow random cracks. Any equipment or procedure which causes raveling or spalling along the crack shall be modified or replaced to prevent raveling or spalling. The joint shall be sealed with sealant in accordance with P-605 or as directed by the Engineer.

ii. Original joint. If the original joint sealant reservoir has been sawed out, the reservoir and as much of the lower saw cut as possible shall be filled with epoxy resin, Type IV, Grade 2, thoroughly tooled into the void using approved procedures.

If only the original narrow saw cut has been made, it shall be cleaned and pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures.

Where a parallel crack goes part way across paving lane and then intersects and follows the original joint which is cracked only for the remained of the width, it shall be treated as specified above for a parallel crack, and the cracked original joint shall be prepared and sealed as originally designed.

(2) Full depth cracks and original joint cracked. If there is any place in the lane width where a parallel crack and a cracked portion of the original joint overlap, the entire slab containing the crack shall be removed and replaced.

d. Removal and replacement of full slabs. Make a full depth double cut perpendicular to the slab surface along all edges of the slab with a concrete saw cutting any dowels or tie-bars. Remove damaged slab protecting adjacent pavement from damage. Damage to adjacent slabs may result in removal of additional slabs as directed by the Construction Manager at the Contractor's expense.

The underlying material shall be repaired, re-compacted and shaped to grade.

Dowels of the size and spacing specified for other joints in similar pavement on the project shall be installed along all four (4) edges of the new slab in accordance with paragraph 501-4.10d.

Placement of concrete shall be as specified for original construction. The joints around the new slab shall be prepared and sealed as specified for original construction.

e. Spalls along joints. Spalls shall be repaired in accordance with P-607.

f. Diamond grinding of Concrete surfaces. Diamond grinding of the hardened concrete should not be performed until the concrete is at least 14 days old and has achieved full minimum strength. Equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints will not be permitted. The depth of diamond grinding shall not exceed 1/2 inch (13 mm) and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified.

Diamond grinding shall be performed with a machine specifically designed for diamond grinding capable of cutting a path at least 3 feet (0.9 m) wide. The saw blades shall be 1/8-inch (3-mm) wide with sufficient number of flush cut blades that create grooves between 0.090 and 0.130 inches (2 and 3.5 mm) wide; and peaks and ridges approximately 1/32 inch (1 mm) higher than the bottom of the grinding cut. The Contractor shall determine the number and type of blades based on the hardness of the aggregate. Contractor shall demonstrate to the Construction Manager that the grinding equipment will produce satisfactory results prior to making corrections to surfaces.

Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The slurry resulting from the grinding operation shall be continuously removed and the pavement left in a clean condition. All grinding shall be at the expense of the Contractor.

CONTRACTOR QUALITY CONTROL (CQC)

501-5.1 Quality control program. The Contractor shall develop a Quality Control Program in accordance with Item C-100. No partial payment will be made for materials that are subject to specific quality control requirements without an approved quality control program.

501-5.2 Contractor quality control (CQC). The Contractor shall provide or contract for testing facilities in accordance with Item C-100. The Construction Manager shall be permitted unrestricted access to inspect the Contractor's QC facilities and witness QC activities. The Construction Manager will advise the Contractor in writing of any noted deficiencies concerning the QC facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting the test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

501-5.3 Contractor QC testing. The Contractor shall perform all QC tests necessary to control the production and construction processes applicable to this specification and as set forth in the CQCP. The testing program shall include, but not necessarily be limited to, tests for aggregate gradation, aggregate moisture content, slump, and air content. A QC Testing Plan shall be developed and approved by the Construction Manager as part of the CQCP.

The Construction Manager may at any time, notwithstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of concrete mixture which is rendered unfit for use due to contamination, segregation, or improper slump. Such rejection may be based on only visual inspection. In the event of such rejection, the Contractor may take a representative sample of the rejected material in the presence of the Construction Manager, and if it can be demonstrated in the laboratory, in the presence of the Construction Manager, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

a. Fine aggregate.

(1) Gradation. A sieve analysis shall be made at least twice daily in accordance with ASTM C136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C70 or ASTM C566.

(3) **Deleterious substances.** Fine aggregate as delivered to the mixer shall be tested for deleterious substances in fine aggregate for concrete as specified in paragraph 501-2.1b, prior to production of the control strip, and a minimum of every 30-days during production or more frequently as necessary to control deleterious substances.

b. Coarse Aggregate.

(1) Gradation. A sieve analysis shall be made at least twice daily for each size of aggregate. Tests shall be made in accordance with ASTM C136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C566.

(3) Deleterious substances. Coarse aggregate as delivered to the mixer shall be tested for deleterious substances in coarse aggregate for concrete as specified in paragraph 501-2.1c, prior to production of the control strip, and a minimum of every 30-days during production or more frequently as necessary to control deleterious substances.

c. Slump. One test shall be made for each sublot. Slump tests shall be performed in accordance with ASTM C143 from material randomly sampled from material discharged from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.

d. Air content. One test shall be made for each sublot. Air content tests shall be performed in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag or other porous coarse aggregate, from material randomly sampled from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.

e. Unit weight and Yield. One test shall be made for each sublot. Unit weight and yield tests shall be in accordance with ASTM C138. The samples shall be taken in accordance with ASTM C172 and at the same time as the air content tests.

f. Temperatures. Temperatures shall be checked at least four times per lot at the job site in accordance with ASTM C1064.

g. Smoothness for Contractor Quality Control.

The Contractor shall perform smoothness testing in transverse and longitudinal directions daily to verify that the construction processes are producing pavement with variances less than ¹/₄ inch in 12 feet, identifying areas that may pond water which could lead to hydroplaning of aircraft. If the smoothness criteria is not met, appropriate changes and corrections to the construction process shall be made by the Contractor before construction continues

The Contractor may use a 12-foot (3.7 m) straightedge, a rolling inclinometer meeting the requirements of ASTM E2133 or rolling external reference device that can simulate a 12-foot (3.7m) straightedge approved by the Engineer. Straight-edge testing shall start with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. Testing shall be continuous across all joints. The surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between the two high points. If the rolling inclinometer or external device is used, the data may be evaluated using the FAA profile program, ProFAA, using the 12-foot straightedge simulation function.

Smoothness readings shall not be made across grade changes or cross slope transitions. The transition between new and existing pavement shall be evaluated separately for conformance with the plans.

(1) Transverse measurements. Transverse measurements shall be taken for each day's production placed. Transverse measurements shall be taken perpendicular to the pavement centerline each 50 feet (15 m) or more often as determined by the Construction Manager. The joint between lanes shall be tested separately to facilitate smoothness between lanes.

(2) Longitudinal measurements. Longitudinal measurements shall be taken for each day's production placed. Longitudinal tests shall be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20 feet (6 m); and at the third points of paving lanes when widths of paving lanes are 20 ft (6 m) or greater.

Deviations on the final surface course in either the transverse or longitudinal direction that will trap water greater than 1/4 inch (6 mm) shall be corrected with diamond grinding per paragraph 501-4.19f or by removing and replacing the surface course to full depth. Grinding shall be tapered in all directions to provide smooth transitions to areas not requiring grinding. All areas in which diamond grinding has been performed shall be subject to the final pavement thickness tolerances specified in paragraph 501-6.6.

Control charts shall be kept to show area of each day's placement and the percentage of corrective grinding required. Corrections to production and placement shall be initiated when corrective grinding is required. If the Contractor's machines and/or methods produce significant areas that need corrective actions in excess of 10 percent of a day's production, production shall be stopped until corrective measures are implemented by the Contractor.

h. Grade. Grade will be evaluated prior to and after placement of the concrete surface.

Measurements will be taken at appropriate gradelines (as a minimum at center and edges of paving lane) and longitudinal spacing as shown on cross-sections and plans. The final surface of the pavement will not vary from the gradeline elevations and cross-sections shown on the plans by more than 1/2 inch (12 mm) vertically and 0.1 feet (30 mm) laterally. The documentation will be provided by the Contractor to the Construction Manager by the end of the following working day.

Areas with humps or depression that that exceed grade or smoothness and that retain water on the surface must be ground off provided the course thickness after grinding is not more than 1/2 inch (12 mm) less than the thickness specified on the plans. If these areas cannot be corrected with grinding then the slabs that are retaining water must be removed and replaced in accordance with paragraph 501-4.19d. Grinding shall be in accordance with paragraph 501-4.19f. All corrections will be at the Contractors expense.

501-5.4 Control charts. The Contractor shall maintain linear control charts for fine and coarse aggregate gradation, slump, and air content. The Contractor shall also maintain a control chart plotting the coarseness factor/workability factor from the combined gradations in accordance with paragraph 501-2.1d.

Control charts shall be posted in a location satisfactory to the Construction Manager and shall be kept up to date at all times. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and suspension Limits, or Specification limits, applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a potential problem and the Contractor is not taking satisfactory corrective action, the Construction Manager may halt production or acceptance of the material.

a. Fine and coarse aggregate gradation. The Contractor shall record the running average of the last five gradation tests for each control sieve on linear control charts. Superimposed on the control charts shall be the action and suspension limits. Gradation tests Shall be performed by the Contractor per ASTM C136. The Contractor shall take at least two samples per lot to check the final gradation. Sampling shall be per ASTM D75 from the flowing aggregate stream or conveyor belt.

b. Slump and air content. The Contractor shall maintain linear control charts both for individual measurements and range (that is, difference between highest and lowest measurements) for slump and air content in accordance with the following Action and Suspension Limits.

c. Combined gradation. The Contractor shall maintain a control chart plotting the coarseness factor and workability factor on a chart in accordance with paragraph 501-2.1d.

Control Donomotor	Individual Measurements	
	Action Limit	Suspension Limit
Gradation ²	*3	*3
Coarseness Factor (CF)	±3.5	±5
Workability Factor (WF)	±2	±3
Slump	+0.5 to -1 inch	+1 to -1.5 inch
	(+13 to -25 mm)	(+25 to -38 mm)
Air Content	±1.5%	±2.0%

Control Chart Limits¹

¹ Control charts shall developed and maintained for each control parameter indicated.

² Control charts shall be developed and maintained for each sieve size.

³ Action and suspension limits shall be determined by the Contractor.

501-5.5 Corrective action at suspension limit. The CQCP shall indicate that appropriate action shall be taken when the process is believed to be out of control. The CQCP shall detail what action will be taken to bring the process into control and shall contain sets of rules to gauge when a process is out of control. As a minimum, a process shall be deemed out of control and corrective action taken if any one of the following conditions exists.

a. Fine and coarse aggregate gradation. When two consecutive averages of five tests are outside of the suspension limits, immediate steps, including a halt to production, shall be taken to correct the grading.

b. Coarseness and Workability factor. When the CF or WF reaches the applicable suspension limits, the Contractor, immediate steps, including a halt to production, shall be taken to correct the CF and WF.

c. Fine and coarse aggregate moisture content. Whenever the moisture content of the fine or coarse aggregate changes by more than 0.5%, the scale settings for the aggregate batcher and water batcher shall be adjusted.

d. Slump. The Contractor shall halt production and make appropriate adjustments whenever:

(1) one point falls outside the Suspension Limit line for individual measurements

OR

(2) two points in a row fall outside the Action Limit line for individual measurements.

d. Air content. The Contractor shall halt production and adjust the amount of air-entraining admixture whenever:

(1) one point falls outside the Suspension Limit line for individual measurements

OR

(2) two points in a row fall outside the Action Limit line for individual measurements.

MATERIAL ACCEPTANCE

501-6.1 Quality assurance (QA) acceptance sampling and testing. All acceptance sampling and testing necessary to determine conformance with the requirements specified in this section, with the exception of coring for thickness determination, will be performed by the Construction Manager. The Contractor shall provide adequate facilities for the initial curing and testing of the strength specimens. The Contractor shall also bear the cost of providing curing facilities and coring and filling operations, per paragraph 501-6.5b(1).

The curing, except for the initial cure period, will be accomplished using the immersion in saturated lime water method. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60° to 80° F (16° to 27° C), and loss of moisture from the specimens must be prevented. The specimens may be stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather, or in heavyweight closed plastic bags, or using other suitable methods, provided the temperature and moisture loss requirements are met.

501-6.2 Quality assurance (QA) testing laboratory. Quality assurance testing organizations performing these acceptance tests will be accredited in accordance with ASTM C1077. The quality assurance laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods will be submitted to the Construction Manager prior to start of construction.

501-6.3 Lot size. Concrete will be accepted for strength and thickness on a lot basis. A lot will consist of a day's production not to exceed 2,000 cubic yards (1530 cubic meters). Each lot will be divided into approximately equal sublots with individual sublots between 400 to 600 cubic yards. Where three sublots are produced, they will constitute a lot. Where one or two sublots are produced, they will be incorporated

into the previous or next lot. Where more than one plant is simultaneously producing concrete for the job, the lot sizes will apply separately for each plant.

501-6.4 Partial lots. When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot or for overages or minor placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

Where three sublots have been produced, they will constitute a lot. Where one or two sublots have been produced, they will be incorporated into the next lot or the previous lot and the total number of sublots will be used in the acceptance criteria calculation, that is, n=5 or n=6.

501-6.5 Acceptance sampling and testing.

a. Strength.

(1) **Sampling.** One sample will be taken for each sublot from the concrete delivered to the job site. Sampling locations will be determined by the Construction Manager in accordance with random sampling procedures contained in ASTM D3665. The concrete will be sampled in accordance with ASTM C172.

(2) Test Specimens. The Construction Manager will be responsible for the casting, initial curing, transportation, and curing of specimens in accordance with ASTM C31. Two (2) specimens will be made from each sample and slump, air content, unit weight, and temperature tests will be conducted for each set of strength specimens. Within 24 to 48 hours, the samples will be transported from the field to the laboratory while in the molds. Samples will be cured in saturated lime water.

The strength of each specimen will be determined in accordance with ASTM C78. The strength for each sublot will be computed by averaging the results of the two test specimens representing that sublot.

(3) Acceptance. Acceptance of pavement for strength will be determined by the Construction Manager in accordance with paragraph 501-6.6b(1). All individual strength tests within a lot will be checked for outliers in accordance with ASTM E178, at a significance level of 5%. Outliers will be discarded and the remaining test values will be used to determine acceptance in accordance with paragraph 501-6.5b.

(4) Curing and Testing Laboratory. The Contractor must provide a fully equipped concrete curing and flexural strength testing laboratory located at the jobsite. It shall have adequate temperature control equipment for curing the concrete specimens and for the performance of the flexural strength tests required by these specifications. The Contractor shall be responsible for providing and paying all utilities necessary to operate the laboratory.

The effective working area of the laboratory shall be a minimum of 625 square feet (12-foot minimum width) with a ceiling height of not less than 8 feet. Lighting shall be adequate to illuminate all areas within the laboratory and for providing exterior lighting for nighttime work. It shall be equipped with heating and air conditioning units to maintain a temperature 70 F +/-5F.

Laboratory facilities shall be kept clean and all equipment shall be maintained in proper working condition. The Engineer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies. When the deficiencies are serious enough to be adversely affecting the test results, the incorporation of the materials into the work will be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected. In the case of 28-day flexural strength testing; testing in an improperly temperature

controlled facility that does not meet standards may, at the discretion of the Engineer, invalidate the test results.

(5) Flexural Beam Testing Equipment. The Engineer shall provide a beam testing machine to conduct the required flexural strength testing. The machine shall be solely dedicated to this project or other Reno-Tahoe International Airport projects at the discretion of the Engineer.

The beam testing machine shall meet the following minimum requirements:

- a. Shall meet the requirements of ASTM C78, and
- b. Shall have fixed top and bottom loading heads, and
- c. Shall have digital load rate and total load indicators, and
- d. Shall be tested and certified per ASTM E4 prior to operation, and
- e. Shall be evaluated by and meet the minimum loading uniformity criteria established by Construction Technology Laboratories, Inc., (CTL) Skokie, IL, prior to operation as follows:
 - i. Within-test coefficient of variation shall be less than or equal to 5 percent (all gages at all loads), and
 - ii. Strains distributed to the third-points shall differ by less than 3 percent, and
 - iii. The transverse strain distribution across the beam shall differ by 5 percent or less.

If the machine, as evaluated by CTL, fails to meet the above minimum criteria; the machine shall be rejected for use and the Engineer shall be responsible for providing a replacement machine.

b. Pavement thickness.

(1) Sampling. One core will be taken by the Contractor for each sublot in the presence of the Construction Manager. Sampling locations will be determined by the Construction Manager in accordance with random sampling procedures contained in ASTM D3665. Areas, such as thickened edges, with planned variable thickness, will be excluded from sample locations.

Cores shall be a minimum 4 inch (100 mm) in diameter neatly cut with a core drill. The Contractor will furnish all tools, labor, and materials for cutting samples and filling the cored hole. Core holes will be filled by the Contractor with a non-shrink grout approved by the Construction Manager within one day after sampling.

(2) Testing. The thickness of the cores will be determined by the Construction Manager by the average caliper measurement in accordance with ASTM C174. Each core shall be photographed and the photograph included with the test report.

(3) Acceptance. Acceptance of pavement for thickness will be determined by the Construction Manager in accordance with paragraph 501-6.6.

501-6.6 ACCEPTANCE CRITERIA.

a. General. Acceptance will be based on the following characteristics of the completed pavement discussed in paragraph 501-6.5b:

(1) Strength

(2) Thickness

- (3) Grade
- (4) Profilograph smoothness. Not used.
- (5) Adjustments for repairs

Acceptance for strength, thickness, and grade, will be based on the criteria contained in accordance with paragraph 501-6.6b(1), 501-6.6b(2), and 501-6.6b(3), respectively.

Production quality must achieve 90 PWL or higher to receive full payment.

Strength and thickness will be evaluated for acceptance on a lot basis using the method of estimating PWL. Production quality must achieve 90 PWL or higher to receive full pavement. The PWL will be determined in accordance with procedures specified in Item C-110.

The lower specification tolerance limit (L) for strength and thickness will be:

Lower Specification Tolerance Limit (L)

Strength	$0.93 \times \text{strength specified in paragraph 501-3.3}$
Thickness	Lot Plan Thickness in inches, - 0.50 in

b. Acceptance criteria.

(1) Strength. If the PWL of the lot equals or exceeds 90%, the lot will be acceptable. Acceptance and payment for the lot will be determined in accordance with paragraph 501-8.1.

(2) Thickness. If the PWL of the lot equals or exceeds 90%, the lot will be acceptable. Acceptance and payment for the lot will be determined in accordance with paragraph 501-8.1.

(3) Grade. The final finished surface of the pavement of the completed project will not vary from the gradeline elevations and cross-sections shown on the plans by more than 1/2 inch (12 mm) vertically or 0.1 feet (30 mm) laterally. The documentation, stamped and signed by a licensed surveyor shall be in accordance with paragraph 501-5.3h. Payment for sublots that do not meet grade for over 25% of the sublot shall reduced by 5% and not be more than 95%.

(4) Adjustments for repair. Sublots with spall repairs, crack repairs, or partial panel replacement, will be limited to no more than 95% payment.

(5) Adjustment for grinding. For sublots with grinding over 25% of a sublot, payment will be reduced 5%.
METHOD OF MEASUREMENT

501-7.1 Concrete pavement shall be measured by the number of square yards (square meters) pavement as specified in-place, completed and accepted. No additional compensation will be made for dowel bars, tie bars, panel reinforcement, thickened edges, grade beams, or jointing as those items shall be considered incidental to the placement of the concrete pavement.

501-7.2 Grade beams are considered incidental to the placement of Concrete pavement and therefore will be included in the measurement in accordance with section 501-7.1. No additional compensation will be made for dowel bars, tie bars, panel reinforcement, thickened edges, or jointing as those items shall be considered incidental to the placement of the concrete pavement.

BASIS OF PAYMENT

501-8.1 Payment. Payment for concrete pavement meeting all acceptance criteria as specified in paragraph 501-6.6. Acceptance Criteria shall be based on results of strength and thickness tests. Payment for acceptable lots of concrete pavement shall be adjusted in accordance with paragraph 501-8.1a for strength and thickness; 501-8.1b for repairs; 501-8.1c for grinding; and 501-8.1d for smoothness, subject to the limitation that:

The total project payment for concrete pavement shall not exceed 100 percent of the product of the contract unit price and the total number of square yards (square meters) of concrete pavement used in the accepted work (See Note 1 under the Price Adjustment Schedule table below).

Payment shall be full compensation for all labor, materials, tools, equipment, and incidentals required to complete the work as specified herein and on the drawings.

a. Basis of adjusted payment. The pay factor for each individual lot shall be calculated in accordance with the Price Adjustment Schedule table below. A pay factor shall be calculated for both strength and thickness. The lot pay factor shall be the higher of the two values when calculations for both strength and thickness are 100% or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either strength or thickness is 100% or higher. The lot pay factor shall be the lower of the two values when calculations for both strength and thickness are loss than 100%.

Price Adjustment	Schedule ¹
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PercentageofMaterialsWithinSpecification Limits(PWL)	Lot Pay Factor (Percent of Contract Unit Price)
96 - 100	106
90 - 95	PWL + 10
75 - 90	0.5 PWL + 55
55 - 74	1.4 PWL - 12
Below 55	Reject ²

¹ Although it is theoretically possible to achieve a pay factor of 106% for each lot, actual payment in excess of 100% shall be subject to the total project payment limitation specified in paragraph 501-8.1.

² The lot shall be removed and replaced unless, after receipt of FAA concurrence, the Owner and Contractor agree in writing that the lot will remain; the lot paid at 50% of the contract unit price; and the total project payment limitation reduced by the amount withheld for that lot.

For each lot accepted, the adjusted contract unit price shall be the product of the lot pay factor for the lot and the contract unit price. Payment shall be subject to the total project payment limitation specified in paragraph 501-8.1. Payment in excess of 100% for accepted lots of concrete pavement shall be used to offset payment for accepted lots of concrete pavement that achieve a lot pay factor less than 100%; except for rejected lots which remain in place and/or sublots with adjustments for repairs.

b. Adjusted payment for repairs. The PWL lot pay factor shall be reduced by 5% and be no higher than 95% for sublots which contain repairs in accordance with paragraph 501-4.19 on more than 20% of the slabs within the sublot. Payment factors greater than 100 percent for the strength and thickness cannot be used to offset adjustments for repairs.

c. Adjusted payment for grinding. The PWL lot pay factor shall be reduced by 5% and be no higher than 95% for sublots with grinding over 25% of a sublot.

Payment. Payment shall be made under:

Item P-501-1 Portland Cement Concrete Pavement (17 inch thick) - per square yard (square meter)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM A184	Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

ASTM A704	Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
ASTM A706	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A775	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A884	Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement
ASTM A934	Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A996	Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM A1035	Standard Specification for Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement
ASTM A1064	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A1078	Standard Specification for Epoxy-Coated Steel Dowels for Concrete Pavement
ASTM C29	Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C70	Standard Test Method for Surface Moisture in Fine Aggregate
ASTM C78	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C94	Standard Specification for Ready-Mixed Concrete
ASTM C114	Standard Test Methods for Chemical Analysis of Hydraulic Cement
ASTM C117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing

ASTM C123	Standard Test Method for Lightweight Particles in Aggregate
ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C138	Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142	Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143	Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150	Standard Specification for Portland Cement
ASTM C171	Standard Specification for Sheet Materials for Curing Concrete
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C174	Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C227	Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C295	Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C311	Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland Cement Concrete
ASTM C494	Standard Specification for Chemical Admixtures for Concrete
ASTM C566	Standard Test Method for Total Evaporable Moisture Content of Aggregates by Drying
ASTM C595	Standard Specification for Blended Hydraulic Cements

ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C642	Standard Test Method for Density, Absorption, and Voids in Hardened Concrete
ASTM C666	Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
ASTM C685	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1017	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1064	Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1077	Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1157	Standard Performance Specification for Hydraulic Cement
ASTM C1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1365	Standard Test Method for Determination of the Proportion of Phases in Portland Cement and Portland-Cement Clinker Using X-Ray Powder Diffraction Analysis
ASTM C1567	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	Standard Specification for Preformed Sponge Rubber and Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction

А	STM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
А	STM D3665	Standard Practice for Random Sampling of Construction Materials
А	STM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
А	STM E178	Standard Practice for Dealing with Outlying Observations
А	STM E1274	Standard Test Method for Measuring Pavement Roughness Using a Profilograph
А	STM E2133	Standard Test Method for Using a Rolling Inclinometer to Measure Longitudinal and Transverse Profiles of a Traveled Surface
American	Concrete Institute (AG	CI)
А	.CI 305R	Guide to Hot Weather Concreting
А	.CI 306R	Guide to Cold Weather Concreting
А	.CI 309R	Guide for Consolidation of Concrete
Advisory	Circulars (AC)	
А	C 150/5320-6	Airport Pavement Design and Evaluation
Federal H	lighway Administration	n (FHWA)
Н	IPERPAV 3, version 3	3.2
Portland (Concrete Association (PCA)
P	CA	Design and Control of Concrete Mixtures, 16th Edition
U.S. Arm	y Corps of Engineers (USACE) Concrete Research Division (CRD)
C	RD C662	Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)

United States Air Force Engineering Technical Letter (ETL)

ETL 97-5 Proportioning Concrete Mixtures with Graded Aggregates for Rigid Airfield Pavements

END ITEM P-501

ITEM P-602 EMULSIFIED ASPHALT PRIME COAT

DESCRIPTION

602-1.1 This item shall consist of an application of emulsified asphalt material on the prepared base course in accordance with these specifications and in reasonably close conformity to the lines shown on the plans.

MATERIALS

602-2.1 Emulsified asphalt material. The emulsified asphalt material shall be as specified in ASTM D3628 for use as a prime coat appropriate to local conditions. The Contractor shall provide a copy of the manufacturer's Certificate of Analysis (COA) for the emulsified asphalt material. The COA shall be provided to and approved by the Engineer before the emulsified asphalt material is applied. The furnishing of the COA for the emulsified asphalt material shall not be interpreted as a basis for final acceptance. The manufacturer's COA may be subject to verification by testing the material delivered for use on the project.

CONSTRUCTION METHODS

602-3.1 Weather limitations. The emulsified asphalt prime coat shall be applied only when the existing surface is dry; the atmospheric temperature is 50° F (10° C) or above, and the temperature has not been below 35° F (2° C) for the 12 hours prior to application; and when the weather is not foggy or rainy. The temperature requirements may be waived when directed by the Construction Manager.

602-3.2 Equipment. The equipment shall include a self-powered pressure asphalt material distributor and equipment for heating asphalt material.

Provide a distributor with pneumatic tires of such size and number that the load produced on the base surface does not exceed 65.0 psi (4.5 kg/sq cm) of tire width to prevent rutting, shoving or otherwise damaging the base, surface or other layers in the pavement structure. Design and equip the distributor to spray the asphalt material in a uniform coverage at the specified temperature, at readily determined and controlled rates from 0.05 to 1.0 gallons per square yard (0.23 to 4.5 L/square meter), with a pressure range of 25 to 75 psi (172.4 to 517.1 kPa) and with an allowable variation from the specified rate of not more than \pm 5%, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying asphalt material manually to areas inaccessible to the distributor. Equip the distributor to circulate and agitate the asphalt material during the heating process. If the distributor is not equipped with an operable quick shutoff valve, the prime operations shall be started and stopped on building paper.

A power broom and power blower suitable for cleaning the surfaces to which the asphalt coat is to be applied shall be provided.

Asphalt distributors must be calibrated annually in accordance with ASTM D2995. The Contractor must furnish a current calibration certification for the asphalt distributor truck from any State or other agency as approved by the RPR.

602-3.3 Application of emulsified asphalt material. Immediately before applying the prime coat, the full width of the surface to be primed shall be swept with a power broom to remove all loose dirt and other objectionable material.

The asphalt emulsion material shall be uniformly applied with an asphalt distributor at the rate of 0.15 to 0.30 gallons per square yard (0.68 to 1.36 liters per square meter) depending on the base course surface texture. The type of asphalt material and application rate shall be approved by the Engineer prior to application.

Following application of the emulsified asphalt material and prior to application of the succeeding layer of pavement, allow the asphalt coat to cure and to obtain evaporation of any volatiles or moisture. Maintain the coated surface until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and recoating deficient areas. Allow the prime coat to cure without being disturbed for a period of at least 48 hours or longer, as may be necessary to attain penetration into the treated course. Furnish and spread sand to effectively blot up and cure excess asphalt material. The Contractor shall remove blotting sand prior to asphalt concrete lay down operations at no additional expense to the Owner. Keep traffic off surfaces freshly treated with asphalt material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces.

602-3.4 Trial application rates. The Contractor shall apply a minimum of three lengths of at least 100 feet (30 m) for the full width of the distributor bar to evaluate the amount of emulsified asphalt material that can be satisfactorily applied with the equipment. Apply three different application rates of emulsified asphalt materials within the application range specified in paragraph 602-3.3. Other trial applications can be made using various amounts of material as directed by the Construction Manager. The trial application is to demonstrate the equipment can uniformly apply the emulsified asphalt material within the rates specified and determine the application rate for the project.

602-3.5 Freight and waybills. The Contractor shall submit waybills and delivery tickets during the progress of the work. Before the final estimate is allowed, file with the Construction Manager certified waybills and certified delivery tickets for all emulsified asphalt materials used in the construction of the pavement covered by the contract. Do not remove emulsified asphalt material from storage until the initial outage and temperature measurements have been taken. The delivery or storage units will not be released until the final outage has been taken.

METHOD OF MEASUREMENT

602-4.1 There shall be no direct measurement for work under this item.

BASIS OF PAYMENT

602-5.1 There shall be no direct payment for work under this item. Payment shall be considered under related items of work.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM D2995	Standard Applicatio	Practice n Rate of	for Bitu	Estimating minous Distr	Application ibutors	Rate	and	Residual
ASTM D3628	Standard P	Practice for	or Sel	ection and U	se of Emulsifi	ied Asp	ohalts	

END OF ITEM P-602

ITEM P-603 EMULSIFIED ASPHALT TACK COAT

DESCRIPTION

603-1.1 This item shall consist of preparing and treating an asphalt or concrete surface with asphalt material in accordance with these specifications and in reasonably close conformity to the lines shown on the plans.

MATERIALS

603-2.1 Asphalt materials. The asphalt material shall be an emulsified asphalt as specified in ASTM D3628 as an asphalt application for tack coat appropriate to local conditions. The emulsified asphalt shall not be diluted. The Contractor shall provide a copy of the manufacturer's Certificate of Analysis (COA) for the asphalt material to the Engineer before the asphalt material is applied for review and acceptance. The furnishing of COA for the asphalt material shall not be interpreted as a basis for final acceptance. The manufacturer's COA may be subject to verification by testing the material delivered for use on the project.

CONSTRUCTION METHODS

603-3.1 Weather limitations. The tack coat shall be applied only when the existing surface is dry and the atmospheric temperature is 50° F (10° C) or above; the temperature has not been below 35° F (2° C) for the 12 hours prior to application; and when the weather is not foggy or rainy. The temperature requirements may be waived when directed by the Construction Manager.

603-3.2 Equipment. The Contractor shall provide equipment for heating and applying the emulsified asphalt material. The emulsion shall be applied with a manufacturer-approved computer rate-controlled asphalt distributor. The equipment shall be in good working order and contain no contaminants or diluents in the tank. Spray bar tips must be clean, free of burrs, and of a size to maintain an even distribution of the emulsion. Any type of tip or pressure source is suitable that will maintain predetermined flow rates and constant pressure during the application process with application speeds under eight (8) miles per hour (13 km per hour) or seven (700) feet per minute (213 m per minute).

The equipment will be tested under pressure for leaks and to ensure proper set-up before use to verify truck set-up (via a test-shot area), including but not limited to, nozzle tip size appropriate for application, spraybar height and pressure and pump speed, evidence of triple-overlap spray pattern, lack of leaks, and any other factors relevant to ensure the truck is in good working order before use.

The distributor truck shall be equipped with a minimum 12-foot (3.7-m) spreader spray bar with individual nozzle control with computer-controlled application rates. The distributor truck shall have an easily accessible thermometer that constantly monitors the temperature of the emulsion, and have an operable mechanical tank gauge that can be used to cross-check the computer accuracy. If the distributor is not equipped with an operable quick shutoff valve, the prime operations shall be started and stopped on building paper.

The distributor truck shall be equipped to effectively heat and mix the material to the required temperature prior to application as required. Heating and mixing shall be done in accordance with the manufacturer's recommendations. Do not overheat or over mix the material.

The distributor shall be equipped with a hand sprayer.

Asphalt distributors must be calibrated annually in accordance with ASTM D2995. The Contractor must furnish a current calibration certification for the asphalt distributor truck from any State or other agency as approved by the Construction Manager.

A power broom and/or power blower suitable for cleaning the surfaces to which the asphalt tack coat is to be applied shall be provided.

603-3.3 Application of emulsified asphalt material. The emulsified asphalt shall not be diluted. Immediately before applying the emulsified asphalt tack coat, the full width of surface to be treated shall be swept with a power broom and/or power blower to remove all loose dirt and other objectionable material.

The emulsified asphalt material shall be uniformly applied with an asphalt distributor at the rates appropriate for the conditions and surface specified in the table below. The type of asphalt material and application rate shall be approved by the Engineer prior to application.

Surface Type	Residual Rate, gal/SY (L/square meter)	Emulsion Application Bar Rate, gal/SY (L/square meter)
New asphalt	0.02-0.05 (0.09-0.23)	0.03-0.07 (0.13-0.32)
Existing asphalt	0.04-0.07 (0.18-0.32)	0.06-0.11 (0.27-0.50)
Milled Surface	0.04-0.08 (0.18-0.36)	.0.06-0.12 (0.27-0.54)
Concrete	0.03-0.05 (0.13-0.23)	0.05-0.08 (0.23-0.36)

Emulsified Asphalt

After application of the tack coat, the surface shall be allowed to cure without being disturbed for the period of time necessary to permit drying and setting of the tack coat. This period shall be determined by the Construction Manager. The Contractor shall protect the tack coat and maintain the surface until the next course has been placed. When the tack coat has been disturbed by the Contractor, tack coat shall be reapplied at the Contractor's expense.

603-3.4 Freight and waybills. The Contractor shall submit waybills and delivery tickets, during progress of the work. Before the final statement is allowed, file with the Construction Manager certified waybills and certified delivery tickets for all emulsified asphalt materials used in the construction of the pavement covered by the contract. Do not remove emulsified asphalt material from storage until the initial outage and temperature measurements have been taken. The delivery or storage units will not be released until the final outage has been taken.

METHOD OF MEASUREMENT

603-4.1 There shall be no direct measurement for work under this item.

BASIS OF PAYMENT

603.5-1 There shall be no direct payment for work under this item. Payment shall be considered under related items of work.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

END

ASTM D1250	Standard Guide for Use of the Petroleum Measurement Tables
ASTM D2995	Standard Practice for Estimating Application Rate and Residual Application Rate of Bituminous Distributors
ASTM D3628	Standard Practice for Selection and Use of Emulsified Asphalts
ITEM P-603	

ITEM P-604 COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS

DESCRIPTION

604-1.1 This item shall consist of preformed polychloroprene compression seals used for sealing joints of rigid pavements.

MATERIALS

604-2.1 Compression seals. Compression joint seal materials shall be a vulcanized elastomeric compound using polychloroprene as the only base polymer. The material and the manufactured seal shall conform to ASTM D2628 and Corps of Engineers Concrete Research Division (CRD) C548.

The joint seal shall be a labyrinth type seal. The uncompressed depth of the face of the compression seal (that is to be bonded to the joint wall) shall be greater than the uncompressed width of the seal, except that for seals one inch (25 mm) or greater in width, the depth need be only one inch (25 mm) or greater. The actual width of the uncompressed seal shall be as recommended by the joint seal manufacturer for the type and width of joints as shown on the plans. The tolerance on the seal shall be +1/8 inch or -1/16 inch (+3 mm or -2 mm), below the top of the pavement surface or bottom of groove for grooved pavement.

The Contractor shall provide a copy of the manufacturer's Certificate of Analysis (COA) for the joint seal material delivered to the project. The COA shall be provided to and approved by the Engineer before the material is installed. The furnishing of the vendor's certified test report shall not be interpreted as a basis for final acceptance. The manufacturer's COA may be subject to verification by testing the material delivered for use on the project.

Materials delivered to the job site shall be inspected for defects, unloaded, and stored with a minimum of handling to avoid damage. Storage facilities shall be provided at the job site to protect materials from weather and maintain materials at temperatures recommended by the manufacturer.

Representative sample of joint seal material will be sampled and retained by the Construction Manager for possible testing.

604-2.2 Lubricant / adhesive. Lubricant/adhesive used for the compression elastomeric joint seal shall be a one-component compound conforming to ASTM D2835.

CONSTRUCTION METHODS

604-3.1 Equipment. Machines, tools, and equipment used in the performance of the work required by this section shall be approved by the Construction Manager before the work starts and shall be maintained by the Contractor in satisfactory condition at all times.

a. Joint cleaning equipment.

(1) Concrete saw. A self-propelled power saw with water-cooled diamond saw blades shall be provided for cutting joints to the depths and widths specified and for removing filler, existing old joint seal or other material embedded in the joints or adhered to the joint faces.

(2) Waterblasting equipment. Waterblasting equipment shall include a trailer-mounted water tank, pumps, high-pressure hose, a wand with safety release cutoff controls, nozzle, and auxiliary water

resupply equipment. The water tank and auxiliary water resupply equipment shall be of sufficient capacity to permit continuous operations. The pumps, hoses, wand, and nozzle shall be of sufficient capacity to permit the cleaning of both walls of the joint and the pavement surface for a width of at least 1/2 inch (12 mm) on either side of the joint. The pump shall be capable of supplying a pressure of at least 3,000 psi (20.7 MPa). A pressure gauge mounted at the pump shall show at all times the pressure in pounds per square inch (psi) (kPa) at which the equipment is operating.

(3) Sandblasting equipment. Sandblasting equipment shall include an air compressor, hose, and a long-wearing venturi-type nozzle of proper size, shape, and opening. The maximum nozzle opening should not exceed 1/4 inch (6 mm). The air compressor shall be portable and shall be capable of furnishing not less than 150 cubic feet (4200 liters) per minute and maintaining a line pressure of not less than 90 psi (620 kPa) at the nozzle while in use. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint about one inch (25 mm) above the pavement surface and will direct the blast to clean the joint walls. The height, angle of inclination, and the size of the nozzle shall be adjusted as necessary to ensure satisfactory results. Contractor shall ensure compliance with Osha Respirable Crystalline Silica Standards.

b. Sealing equipment. Equipment used to install the compression seal shall place the compression seal to the prescribed depths within the specified tolerances without cutting, nicking, twisting, or otherwise damaging the seal. The equipment shall not stretch or compress the seal more than 2.0% longitudinally during installation. The machine shall be an automatic self-propelled joint seal application equipment and shall be engine powered. The machine shall include a reservoir for the lubricant/adhesive, a device for conveying the lubricant/adhesive in the proper quantities to the sides the preformed seal or the sidewalls of the joint, a reel capable of holding one full spool of compression seal, and a power-driven apparatus for feeding the joint seal through a compression device and inserting the seal into the joint. The equipment shall also include a guide to maintain the proper course along the joint being sealed. The machine shall all times be operated by an experienced operator.

Hand operated joint seal application equipment may be used for localized areas and for projects less than 500 square yards (450 square meters). The equipment shall be a two-axle, four-wheel machine that includes means for compressing and inserting the compression seal into the joint and a reel capable of holding one full spool of compression seal material.

CONSTRUCTION METHODS

604-4.1 Environmental conditions. The ambient temperature and the pavement temperature within the joint wall shall be at least 35°F (2°C) and rising at the time of installation of the materials. Sealant application will not be permitted if moisture or any foreign material is observed in the joint.

604-4.2 Trial and joint seal and lubricant / **adhesive installation.** Prior to the cleaning and sealing of the joints for the entire project, a control strip at least 200 feet (69 meters) long shall be prepared at a location designated by the Construction Manager using the specified materials and the approved equipment, to demonstrate the materials and construction processes for joint preparation and sealing of all types of joints included in the project. No other joints shall be sealed until the test installation has been approved by the Construction Manager.

If materials or installation do not meet requirements, the materials shall be removed, and the joints shall be cleaned and a new trial joint seal installation shall be performed at the Contractor's expense. The Construction Manager approved trial section will be incorporated into the permanent work.

604-4.3 Preparation of joints. Immediately before installation of the compression joint seal, the joints shall be thoroughly cleaned to remove all laitance, filler, existing sealer, foreign material and protrusions of hardened concrete from the sides and upper edges of the joint space to be sealed. Cleaning shall extend along pavement surfaces at least 1/2 inch (12 mm) on either side of the joint. After final cleaning and immediately prior to sealing, the joints shall be blown out with compressed air and left free of debris and water. Any irregularity in the joint face that would prevent uniform contact between the joint seal and the joint face shall be corrected prior to the installation of the joint seal.

a. Sawing. Joints shall be sawed to clean and to open them to the full specified width and depth. Immediately following the sawing operation, the joint faces and opening shall be thoroughly cleaned using a water jet to remove all saw cuttings or debris remaining on the faces or in the joint opening. Compression seal shall be installed within three (3) calendar days of the time the joint cavity is sawed. Depth of the joint cavity shall be in accordance with manufacturer's instructions. Submit printed copies of manufacturers' instructions 30 days prior to use on the project. The saw cut for the joint seal cavity shall at all locations be centered over the joint line. The nominal width of the sawed joint seal cavity shall be as follows; the actual width shall be within a tolerance of $\pm 1/16$ inch (2 mm):

(1) If a nominal 13/16 inch (21 mm) wide compression seal is furnished, the nominal width of the saw cut shall be 1/2 inches (125 mm) when the pavement temperature at the time of sawing is between 25 and 80°F (0 and 25°C). If the pavement temperature at the time of sawing is above this range, the nominal width of the saw cut shall be decreased 1/16 inch (2 mm). If the pavement temperature at the time of sawing is below this range, the nominal width of the saw cut shall be increased 1/16 inch (2 mm).

(2) If a nominal one inch (25 mm) wide compression seal is furnished, the nominal width of the saw cut shall be 9/16 inches (140 mm) when the pavement temperature at the time of sawing is between 25 and 140°F (0 and 60°C). If the pavement temperature at the time of sawing is above this range, the nominal width of the saw cut shall be decreased 1/16 inch (2 mm). If the pavement temperature at the time of sawing is below this range, the nominal width of the saw cut shall be increased 1/16 inch (2 mm).

(3) The pavement temperature shall be measured and recorded in the presence of the Construction Manager. Measurement shall be made each day before commencing sawing and at any other time during the day when the temperature appears to be moving out of the allowable sawing range.

b. Waterblast cleaning. The concrete joint faces and pavement surfaces extending at least 1/2 inch (12 mm) from the joint edges shall be waterblasted clean. A multiple pass technique shall be used until the surfaces are free of dust, dirt, curing compound, or any residue that might prevent ready insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete. After final cleaning and immediately prior to sealing, the joints shall be blown out with compressed air and left completely free of debris and water.

c. Sandblast cleaning. The concrete joint faces and pavement surfaces extending at least 1/2 inch (12 mm) from the joint edges shall be sandblasted clean. A multiple pass technique shall be used until the surfaces are free of dust, dirt, curing compound, or any residue that might prevent ready insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete. After final cleaning and immediately prior to sealing, the joints shall be blown out with compressed air and left completely free of debris and water. Contractor shall ensure compliance with Osha Respirable Crystalline Silica Standards.

d. Rate of progress. Cleaning of the joint faces shall be limited to the linear footage of joint that can be sealed during the same workday.

604-4.4 Installation of the compression seal.

a. Time of installation. Joints shall be sealed within 7 calendar days of sawing the joint seal cavity and the final cleaning of the joint walls, or a temporary seal shall be installed to prevent infiltration of foreign material. If rain interrupts the sealing operations, the joints shall be washed, cleaned with air and be dry before proceeding with installing of the lubricant/adhesive and compression seal.

b. Installation Sequence. Longitudinal joints shall be sealed first, then seal the transverse joints. Transverse joint seals will be continuous from edge to edge of the pavement. Intersections shall be made monolithic by use of joint seal adhesive and care in fitting the intersection parts together. Seals which do not reach an intersection shall be removed and replaced with new seal as directed by the Construction Manager at the Contractor's Expense. Seal extender pieces shall not be used at intersections.

c. Sealing joints. The sides of the joint seal or the sides of the joint shall be covered with a coating of lubricant/adhesive and the seal installed as specified. Butt joints and seal intersections shall be coated with liberal applications of lubricant/adhesive. Lubricant/adhesive spilled on the pavement shall be removed immediately to prevent setting on the pavement.

The joint seal shall be placed at a uniform depth within the tolerances specified. The compression joint seal shall be placed to a depth of 3/16 inch (5 mm), $\pm 1/8$ inch (3 mm), below the pavement surface or below the depth of the groove unless otherwise directed by the Construction Manager.

The seal shall be installed in the longest practicable lengths in longitudinal joints and shall be cut at the joint intersections to provide continuous installation of the seal in the transverse joints. The joint seal shall be installed in an upright position, free from twisting, distortion, and cuts. If stretch of installed joint seal exceeds 1%, adjustments shall be made to the installation equipment and procedure. Stretch of installed joint seals exceeding 2% stretch shall be removed and replaced.

After installation of the longitudinal joint seals, it shall set for a minimum of one (1) hour prior to cutting the seal at the joint intersections. For all transverse joints, the minimum length of the preformed joint seal shall be the pavement width from edge to edge.

604-4.5 Clean up. Upon completion of the project, all unused materials shall be removed from the site, all lubricant/adhesive on the pavement surface shall be removed, and the pavement shall be left in clean condition.

604-4.6 Quality control and quality assurance.

a. Quality Control The application equipment shall be inspected to assure uniform application of lubricant/adhesive to the sides of the compression joint seal or the walls of the joint. Equipment causing cutting, twisting, nicking, excessive stretching or compressing of the compression seal, or improper application of the lubricant/adhesive, shall not be used until causes of the deficiencies are determined and corrected by the Contractor.

The seal shall be inspected by the Contractor a minimum of once per 400 feet (120 m) of seal for compliance to the shrinkage or compression requirements. Measurements shall be made at the same interval to determine conformance with depth and width installation requirements.

b. Quality Assurance. Cleaned joints shall be approved by the Construction Manager prior to installation of the lubricant/adhesive and compression joint seal.

Conformance to stretching and compression limitations shall be determined by the Construction Manager using the following procedures:

(1) Mark the top surface of the compression seal at one foot (30 cm) intervals in a manner clear and durable to enable length determinations of the seal.

(2) After installation, the distance between the marks on the seal shall be measured by the Contractor.

(3) If the stretching or compression exceeds the specified limit, the seal shall be removed and replaced with new joint seal at the Contractor's Expense. The seal shall be removed up to the last correct measurement.

604-4.7 Acceptance. The joint sealing system (compression seal and lubricant/adhesive) shall be inspected by the Construction Manager for proper rate of cure and bonding to the concrete, cuts, twists, nicks, and other deficiencies. Seals exhibiting any defects prior to final acceptance of the project, shall be removed from the joint, wasted, and replaced with new material in a satisfactory manner, at the Contractor's expense, as determined by the Construction Manager.

METHOD OF MEASUREMENT

604-5.1 Measurement. There shall be no direct measurement for this item.

BASIS OF PAYMENT

604-6.1 Payment. There shall be no direct measurement of this item. Payment for this item shall be considered under similar items of work.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM D2628	Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D2835	Standard Specification for Lubricant for Installation of Preformed Compression Seals in Concrete Pavements
Corps of Engineers	
CRD C548	Standard Specification for Jet-Fuel and Heat Resistant Preformed Polychloroprene Elastomeric Joint Seals for Rigid Pavements
Unified Facilities Criteria (UF	FC)
UFC 3-250-08FA	Standard Practice for Sealing Joints and Cracks in Rigid and Flexible Pavements
	END ITEM P-604

ITEM P-605 JOINT SEALANTS FOR PAVEMENTS

DESCRIPTION

605-1.1 This item shall consist of providing and installing a resilient and adhesive joint sealing material capable of effectively sealing joints in pavement; joints between different types of pavements; and cracks in existing pavement.

MATERIALS

605-2.1 Joint sealants. Joint sealant materials shall meet the requirements of ASTM D5893 or D6690 as indicated on the plans.

Each lot or batch of sealant shall be delivered to the jobsite in the manufacturer's original sealed container. Each container shall be marked with the manufacturer's name, batch or lot number, the safe heating temperature, and shall be accompanied by the manufacturer's certification stating that the sealant meets the requirements of this specification.

605-2.2 Backer rod. The material furnished shall be a compressible, non-shrinking, non-staining, non-absorbing material that is non-reactive with the joint sealant in accordance with ASTM D5249. The backer-rod material shall be $25\% \pm 5\%$ larger in diameter than the nominal width of the joint.

605-2.3 Bond breaking tapes. Provide a bond breaking tape or separating material that is a flexible, non-shrinkable, non-absorbing, non-staining, and non-reacting adhesive-backed tape. The material shall have a melting point at least 5°F (3°C) greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The bond breaker tape shall be approximately 1/8 inch (3 mm) wider than the nominal width of the joint and shall not bond to the joint sealant.

CONSTRUCTION METHODS

605-3.1 Time of application. Joints shall be sealed as soon after completion of the curing period as feasible and before the pavement is opened to traffic, including construction equipment. The pavement temperature shall be 50°F (10° C) and rising at the time of application of the poured joint sealing material. Do not apply sealant if moisture is observed in the joint.

In no case shall construction or other traffic be allowed on pavement that has not either been sealed or had jute or nylon rope temporarily installed within the joint. The rope should be slightly larger than the joint and should be forced into the joint so that the top of the rope is 1/8" (3mm) below the pavement surface. The rope shall be removed immediately prior to cleaning.

605-3.2 Equipment. Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and maintained in satisfactory condition at all times. Submit a list of proposed equipment to be used in performance of construction work including descriptive data, 14 days prior to use on the project.

a. Concrete saw. Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified.

b. Sandblasting equipment. The Contractor must demonstrate sandblasting equipment including the air compressor, hose, guide and nozzle size, under job conditions, before approval in accordance with paragraph 605-3.3. The Contractor shall demonstrate, in the presence of the Construction Manager, that the method cleans the joint and does not damage the joint. Contractor shall ensure compliance with Osha Respirable Crystalline Silica Standards.

c. Waterblasting equipment. The Contractor must demonstrate waterblasting equipment including the pumps, hose, guide and nozzle size, under job conditions, before approval in accordance with paragraph 605-3.3. The Contractor shall demonstrate, in the presence of the Construction Manager, that the method cleans the joint and does not damage the joint.

d. Hand tools. Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces. Hand tools should be carefully evaluated for potential spalling effects prior to approval for use.

e. Hot-poured sealing equipment. The unit applicators used for heating and installing ASTM D6690 joint sealant materials shall be mobile and shall be equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the joint to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. The applicator unit shall be designed so that the sealant will circulate through the delivery hose and return to the inner kettle when not in use.

f. Cold-applied, single-component sealing equipment. The equipment for installing ASTM D5893 single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

605-3.3 Preparation of joints. Pavement joints for application of material in this specification must be dry, clean of all scale, dirt, dust, curing compound, and other foreign matter. The Contractor shall demonstrate, in the presence of the Construction Manager, that the method cleans the joint and does not damage the joint.

a. Sawing. All joints shall be sawed in accordance with specifications and plan details. Immediately after sawing the joint, the resulting slurry shall be completely removed from joint and adjacent area by flushing with a jet of water, and by use of other tools as necessary.

b. Sealing. Immediately before sealing, the joints shall be thoroughly cleaned of all remaining laitance, curing compound, filler, protrusions of hardened concrete, old sealant and other foreign material from the sides and upper edges of the joint space to be sealed. Cleaning shall be accomplished by sandblasting and or waterblaster as specified in paragraph 605-3.2. The newly exposed concrete joint faces and the pavement surface extending a minimum of 1/2 inch (12 mm) from the joint edge shall be sandblasted clean. Sandblasting shall be accomplished in a minimum of two passes. One pass per joint face with the nozzle held at an angle directly toward the joint face and not more than 3 inches (75 mm) from it. After final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water. The joint faces shall be surface dry when the seal is applied.

c. Backer Rod. When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a backer rod in accordance with paragraph 605-2.2 to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backer rod is placed at the specified depth and is not stretched or twisted during installation.

d. Bond-breaking tape. Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond-separating tape breaker in accordance with paragraph 605-2.3 to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Securely bond the tape to the bottom of the joint opening so it will not float up into the new sealant.

605-3.4 Installation of sealants. Joints shall be inspected for proper width, depth, alignment, and preparation, and shall be approved by the Construction Manager before sealing is allowed. Sealants shall be installed in accordance with the following requirements:

Immediately preceding, but not more than 50 feet (15 m) ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill the joints from the bottom up to 1/4 inch $(6 \text{ mm}) \pm 1/16$ inch (2 mm) below the top of pavement surface; or bottom of groove for grooved pavement. Remove and discard excess or spilled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the Construction Manager. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

605-3.5 Inspection. The Contractor shall inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified at no additional cost to the airport.

605-3.6 Clean up. Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

METHOD OF MEASUREMENT

605-4.1 There shall be no direct measurement for this item.

BASIS OF PAYMENT

605-5.1 There shall be no direct payment of this item. Payment for this item shall be considered under similar items of work.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM D789	Standard Test Method for Determination of Relative Viscosity of Polyamide (PA)
ASTM D5249	Standard Specification for Backer Material for Use with Cold- and Hot- Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints
ASTM D5893	Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements
ASTM D6690	Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt
Advisory Circulars (AC)	
AC 150/5340-30	Design and Installation Details for Airport Visual Aids

END ITEM P-605

ITEM P-606 ADHESIVE COMPOUNDS, TWO-COMPONENT FOR SEALING WIRE AND LIGHTS IN PAVEMENT

DESCRIPTION

606-1.1 This specification covers two types of material; a liquid suitable for sealing electrical wire in saw cuts in pavement and for sealing light fixtures or bases in pavement, and a paste suitable for embedding light fixtures in the pavement. Both types of material are two-component filled formulas with the characteristics specified in paragraph 606-2.4. Materials supplied for use with asphalt and/or concrete pavements must be formulated so they are compatible with the asphalt and/or concrete.

MATERIALS

606-2.1 Curing. When pre-warmed to 77°F (25°C), mixed, and placed in accordance with manufacturer's directions, the materials shall cure at temperatures of 45°F (7°C) or above without the application of external heat.

606-2.2 Storage. The adhesive components shall not be stored at temperatures over 86°F (30°C), unless otherwise specified by the manufacturer.

606-2.3 Caution. Installation and use shall be in accordance with the manufacturer's recommended procedures. Avoid prolonged or repeated contact with skin. In case of contact, wash with soap and flush with water. If taken internally, call doctor. Keep away from heat or flame. Avoid vapor. Use in well-ventilated areas. Keep in cool place. Keep away from children.

606-2.4 Characteristics. When mixed and cured in accordance with the manufacturer's directions, the materials shall have the following properties shown in Table 1.

Table 1. Proper	ty Requirements
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Physical or Electrical Property	Minimum	Maximum	ASTM Method	
Tensile	Tensile			
Portland cement concrete	1,000 psi (70 kg/sq cm)		D 638	
Asphalt concrete	500 psi (35 kg/sq cm)			
Elongation				
Portland cement concrete		See note ¹	D 638	
Asphalt concrete	50%		D 638	
Coef. of cub. exp. cu. cm/cu. cm/°C	0.00090	0.00120	D 1168	
Coef. of lin. exp. cm/cm/°C	0.000030	0.000040	D 1168	
Dielectric strength, short time test	350 volts/mil.		D 149	
Arc resistance	125 sec			
Pull-off				
Adhesion to steel	1,000 psi (70 kg/sq cm)			
Adhesion to Portland cement concrete	200 psi (14 kg/sq cm)			
Adhesion to asphalt concrete	No test available.			
Adhesion to aluminum	250 psi			

¹ 20% or more (without filler) for formulations to be supplied for areas subject to freezing.

SAMPLING, INSPECTION, AND TEST PROCEDURES

606-3.1 Tensile properties. Tests for tensile strength and elongation shall be conducted in accordance with ASTM D638.

606-3.2 Expansion. Tests for coefficients of linear and cubical expansion shall be conducted in accordance with, Method B, except that mercury shall be used instead of glycerine. The test specimen shall be mixed in the proportions specified by the manufacturer, and cured in a glass tub approximately 2 inch (50 mm) long by 3/8 inch (9 mm) in diameter. The interior of the tube shall be precoated with a silicone mold release agent. The hardened sample shall be removed from the tube and aged at room temperature for one (1) week before conducting the test. The test temperature range shall be from 35° F (2° C) to 140° F (60° C).

606-3.3 Test for dielectric strength. Test for dielectric strength shall be conducted in accordance with ASTM D149 for sealing compounds to be furnished for sealing electrical wires in pavement.

606-3.4 Test for arc resistance. Test for arc resistance shall be conducted for sealing compounds to be furnished for sealing electrical wires in pavement.

606-3.5 Test for adhesion to steel. The ends of two smooth, clean, steel specimens of convenient size (1 inch by 1 inch by 6 inch) (25 mm by 25 mm by 150 mm) would be satisfactory when bonded together with adhesive mixture and allowed to cure at room temperature for a period of time to meet formulation requirements and then tested to failure on a Riehle (or similar) tensile tester. The thickness of adhesive to be tested shall be 1/4 inch (6 mm).

606-3.6 Adhesion to Portland cement concrete.

a. Concrete test block preparation. The aggregate grading shall be as shown in Table 2.

The coarse aggregate shall consist of crushed rock having a minimum of 75% of the particles with at least one fractured face and having a water absorption of not more than 1.5%. The fine aggregate shall consist of crushed sand manufactured from the same parent rock as the coarse aggregate. The concrete shall have a water-cement ratio of 5.5 gallons (21 liters) of water per bag of cement, a cement factor of $6, \pm 0.5$, bags of cement per cubic yard (0.76 cubic meter) of concrete, and a slump of 2-1/2 inch (60 mm), $\pm 1/2$ inch (60 mm ± 12 mm). The ratio of fine aggregate to total aggregate shall be approximately 40% by solid volume. The air content shall be 5.0%, $\pm 0.5\%$, and it shall be obtained by the addition to the batch of an air-entraining admixture such as Vinsol® resin. The mold shall be of metal and shall be provided with a metal base plate.

Means shall be provided for securing the base plate to the mold. The assembled mold and base plate shall be watertight and shall be oiled with mineral oil before use. The inside measurement of the mold shall be such that several one inch (25 mm) by 2-inch (75 mm) by 3-inch (25 mm by 50 mm by 75 mm) test blocks can be cut from the specimen with a concrete saw having a diamond blade. The concrete shall be prepared and cured in accordance with ASTM C192.

Туре	Sieve Size	Percent Passing
Coarse Aggregate	3/4 inch (19.0 mm)	97 to 100
	1/2 inch (12.5 mm)	63 to 69
	3/8 inch (9.5 mm)	30 to 36
	No. 4 (4.75 mm)	0 to 3
Fine Aggregate	No. 4 (4.75 mm)	100
	No. 8 (2.36 mm)	82 to 88
	No. 16 (1.18 mm)	60 to 70
	No. 30 (600 µm)	40 to 50
	No. 50 (300 µm)	16 to 26
	No. 100 (150 μm)	5 to 9

Table 2. Aggregate for Bond Test Blocks

b. Bond test. Prior to use, oven-dry the test blocks to constant weight at a temperature of 220°F to 230°F (104°C to 110°C), cool to room temperature, $73.4°F \pm 3°F$ (23°C ±1.6°C), in a desiccator, and clean the surface of the blocks of film or powder by vigorous brushing with a stiff-bristled fiber brush. Two test blocks shall be bonded together on the one inch by 3 inch (25 mm by 75 mm) sawed face with the adhesive mixture and allowed to cure at room temperature for a period of time to meet formulation requirements and then tested to failure in a Riehle (or similar) tensile tester. The thickness of the adhesive to be tested shall be 1/4 inch (6 mm).

606-3.7 Compatibility with asphalt mix. Test for compatibility with asphalt in accordance with ASTM D5329.

606-3.8 Adhesive compounds – Contractor's responsibility. The Contractor shall furnish the vendor's certified test reports for each batch of material delivered to the project. The report shall certify that the material meets specification requirements and is suitable for use with concrete and/or asphalt concrete pavements. The report shall be provided to and accepted by the Construction Manager before use of the material. In addition, the Contractor shall obtain a statement from the supplier or manufacturer that guarantees the material for one year. The supplier or manufacturer shall furnish evidence that the material has performed satisfactorily on other projects.

606-3.9 Application. Adhesive shall be applied on a dry, clean surface, free of grease, dust, and other loose particles. The method of mixing and application shall be in strict accordance with the manufacturer's recommendations. When used with Item P-605, such as light can installation, Item P-605 shall not be applied until the Item P-606 has fully cured.

METHOD OF MEASUREMENT

606-4.1 There shall be no direct measurement for this item.

BASIS OF PAYMENT

606-5.1_There shall be no direct payment for this item. Payment for this item will be considered under other similar items of work.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM C192	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM D149	Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D5329	Standard Test Methods for Sealants and Fillers, Hot-applied, for Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements

END OF ITEM P-606

ITEM P-607 SPALL REPAIR

DESCRIPTION

<u>607-1.1</u> This item shall consist of furnishing and installing suitable material to repair concrete pavement damaged during construction. This item does not supersede repair work covered in Item P-501.

Spalls are those areas along the sawn joints that either:

- 1. Have broken concrete resulting in exposure of more than three-fourths (3/4) of the preformed joint seal face, and
- 2. Broken or loose concrete extending more than three-fourths (3/4) of the height of the preformed joint seal face behind the sawn joint face
- 3. Broken or loose concrete extending more than one and one-half (1¹/₂) inches along the sawn joint.

Spall repair shall consist of sawing concrete behind the spalled area, removing concrete pavement to expose sound pavement throughout the repair area, preparing and installing repair material and completion of the sawn joint.

Spalls smaller than the above will be repaired by cleaning the spalled area of all loose material and filling the void with either hot-pour or polyurethane sealant. These types of repair will not be counted as spalls per Section 607-5.1.

<u>607-1.2 IDENTIFICATION.</u> Prior to commencing demolition work on the concrete pavement, the Contractor in the company of the Engineer shall inspect the concrete to remain to identify and mark any spalled areas. Any spalls other than those so identified shall be considered to have been caused by the Contractor. They shall be repaired by the Contractor without additional cost to the Owner and a penalty paid to the Owner.

MATERIALS

<u>607-2.1 ELASTOMERIC CONCRETE.</u> The spall repair material shall be an elastomeric concrete consisting of a fluid base or binder with suitable reinforcing agents to provide a product which mixes in five minutes or less, which flows readily, which strongly adheres to concrete, which requires no external application of heat for curing and which cures within one hour of application. This material shall be Delpatch as manufactured by The D.S. Brown Company or equal meeting the following properties.

PROPERTIES	REQUIREMENT	TEST METHOD	
Tensile			
Strength	600 psi	-	
Elongation	25	-	
Hardness, Durometer D	50	ASTM D2240	
Compressive Stress			
5% Deflection	800 psi min. 1400 psi max	ASTM D695	
Resilience			
5% Deflection	95% min	-	
Impact			
Ball Drop @ -20° F(No cracking)	>10 ft.	-	
Adhesion to Concrete (psi)		-	
Dry Bond	400 min.	-	
Wet Bond	250 min	-	
Fluid Immersion		-	
Percent weight change after 70 hours in Room Temperature Jet Fuel	8% max	ASTM D471	

-2.2 **PROPERTIES.** The material shall meet the following properties:

CONSTRUCTION METHODS

<u>607-3.1 WEATHER LIMITATIONS.</u> Spall repair shall be performed only when the ambient air temperature is 45° F (7°C) and rising. The temperature of the concrete to be repaired shall be 45° F (7°C) or above.

607-3.2 PREPARATION OF SURFACE. Cut area to be repaired to the dimension indicated in the Plans or as directed by the Engineer. Prior to application of the elastomeric concrete, the surface shall be dry and shall be sand blasted to ensure it is free from dirt, grease, oil laitance or other foreign material which may reduce the bond between the spall repair material and the concrete pavement. After sandblasting, primer should be applied to the pavement and allowed to set 30 minutes (minimum) before introducing spall repair material. There shall be no fugitive dust from the sand blasting operation.

<u>607-3.3</u> <u>APPLICATION.</u> Spall repair materials shall be weighed and mixed in accordance with manufacturer's recommendations. The material shall be placed into the area to be repaired in layers up to finished grade within four minutes of the initial mixing. Allow the material to cure two hours before opening to construction traffic.

607-3.4 MANUFACTURER'S REPRESENTATIVE. A representative of agent of the manufacturer shall be present during the initial uses of this product to satisfy himself that it is being properly applied. At such time as the manufacturer is satisfied that the Contractor is properly applying the product and so states in writing to the Engineer, that representative need not be present.

<u>607-4.1 METHOD OF MEASUREMENT.</u> For those areas needing repair new concrete or in concrete pavement to remain, the unit of measurement shall be per spall.

<u>607-5.1 BASIS OF PENALTY.</u> Any deficiencies that must be corrected during construction will result in future maintenance costs that will be borne by the Owner. Therefore the Contractor will be assessed a penalty of Five Hundred (\$500) dollars for each spall repaired, over and above the cost to repair the spall. This penalty will be deducted by the Owner from the funds otherwise due the Contractor under Item P-501.

MATERIAL REQUIREMENTS

- ASTM D395 Standard Test Method for Rubber Property Compression Set
- ASTM D471 Standard Test Method for Rubber Property Effect of Liquids
- ASTM D695 Standard Test Method for Compressive Properties of Rigid Plastics
- ASTM D2240 Standard Test Method for Rubber Property Durometer Hardness
- ASTM D2632 Standard Test Method for Rubber Property Resilience by Vertical Rebound

END OF ITEM P-607

ITEM P-610 CONCRETE FOR MISCELLANEOUS STRUCTURES

DESCRIPTION

610-1.1 This item shall consist of concrete and reinforcement, as shown on the plans, prepared and constructed in accordance with these specifications. This specification shall be used for all concrete other than airfield pavement which are cast-in-place.

MATERIALS

610-2.1 General. Only approved materials, conforming to the requirements of these specifications, shall be used in the work. Materials may be subject to inspection and tests at any time during their preparation or use. The source of all materials shall be approved by the Construction Manager before delivery or use in the work. Representative preliminary samples of the materials shall be submitted by the Contractor, when required, for examination and test. Materials shall be stored and handled to ensure preservation of their quality and fitness for use and shall be located to facilitate prompt inspection. All equipment for handling and transporting materials and concrete must be clean before any material or concrete is placed in them.

The use of pit-run aggregates shall not be permitted unless the pit-run aggregate has been screened and washed, and all fine and coarse aggregates stored separately and kept clean. The mixing of different aggregates from different sources in one storage stockpile or alternating batches of different aggregates shall not be permitted.

a. Reactivity. Fine aggregate and coarse aggregates to be used in all concrete shall have been tested separately within six months of the project in accordance with ASTM C1260. Test results shall be submitted to the Construction Manager. The aggregate shall be considered innocuous if the expansion of test specimens, tested in accordance with ASTM C1260, does not exceed 0.08% at 14 days (16 days from casting). If the expansion either or both test specimen is greater than 0.08% at 14 days, but less than 0.20%, a minimum of 25% of Type F fly ash, or between 40% and 55% of slag cement shall be used in the concrete mix.

If the expansion is greater than 0.20% the aggregates shall not be used, and test results for other aggregates must be submitted for evaluation; or aggregates that meet P-501 reactivity test requirements may be utilized.

610-2.2 Coarse Aggregate. The coarse aggregate for concrete shall meet the requirements of ASTM C33 and the requirements of Table 4, Class Designation 5S; and the grading requirements shown below, as required for the project.

Maximum Aggregate Size	ASTM C33, Table 3 Grading Requirements (Size No.)
1 1/2 inch (37.5 mm)	467 or 4 and 67
1 inch (25 mm)	57
³ / ₄ inch (19 mm)	67
¹ / ₂ inch (12.5 mm)	7

Coarse Aggregate Grading Requirements

610-2.2.1 Course Aggregate Susceptibility to Durability Cracking. Not used.

610-2.3 Fina Aggregate. The fine aggregate for concrete shall meet all fine aggregate requirements of ASTM C33.

610-2.4 Cement. Cement shall conform to the requirements of C150 Type II.

610-2.5 Cementitious Material.

a. Fly ash. Fly ash shall meet the requirements of ASTM C618, with the exception of loss of ignition, where the maximum shall be less than 6%. Fly ash shall have a Calcium Oxide (CaO) content of less than 15% and a total available alkali content less than 3% per ASTM C311. Fly ash produced in furnace operations using liming materials or soda ash (sodium carbonate) as an additive shall not be acceptable. The Contractor shall furnish the previous three most recent, consecutive ASTM C618 reports for each source of fly ash proposed in the concrete mix, and shall furnish each additional report as they become available during the project. The reports can be used for acceptance or the material may be tested independently by the Construction Manager.

b. Slag cement (ground granulated blast furnace (GGBF)). Slag cement shall conform to ASTM C989, Grade 100 or Grade 120. Slag cement shall be used only at a rate between 25% and 55% of the total cementitious material by mass.

610-2.6 Water. Water used in mixing or curing shall be from potable water sources. Other sources shall be tested in accordance with ASTM C1602 prior to use.

610-2.7 Admixtures. The Contractor shall submit certificates indicating that the material to be furnished meets all of the requirements indicated below. In addition, the Engineer may require the Contractor to submit complete test data from an approved laboratory showing that the material to be furnished meets all of the requirements of the cited specifications. Subsequent tests may be made of samples taken by the Construction Manager from the supply of the material being furnished or proposed for use on the work to determine whether the admixture is uniform in quality with that approved.

a. Air-entraining admixtures. Air-entraining admixtures shall meet the requirements of ASTM C260 and shall consistently entrain the air content in the specified ranges under field conditions. The air-entrainment agent and any water reducer admixture shall be compatible.

b. Water-reducing admixtures. Water-reducing admixture shall meet the requirements of ASTM C494, Type A, B, or D. ASTM C494, Type F and G high range water reducing admixtures and ASTM C1017 flowable admixtures shall not be used.

c. Other chemical admixtures. The use of set retarding, and set-accelerating admixtures shall be approved by the CONSTRUCTION MANAGER. Retarding shall meet the requirements of ASTM C494, Type A, B, or D and set-accelerating shall meet the requirements of ASTM C494, Type C. Calcium chloride and admixtures containing calcium chloride shall not be used.

610-2.8 Premolded Joint Material. Premolded joint material for expansion joints shall meet the requirements of ASTM D1751.

610-2.9 Joint Filler. The filler for joints shall meet the requirements of Item P-605, unless otherwise specified.

610-2.10 Steel Reinforcement. Reinforcing shall consist of deformed bars conforming to the requirements of ASTM A615.

610-2.11 Materials for Curing Concrete. Curing materials shall conform to ASTM C309.

CONSTRUCTION METHODS

610-3.1 General. The Contractor shall furnish all labor, materials, and services necessary for, and incidental to, the completion of all work as shown on the drawings and specified here. All machinery and equipment used by the Contractor on the work, shall be of sufficient size to meet the requirements of the work. All work shall be subject to the inspection and approval of the Construction Manager.

610-3.2 Concrete Mixture. The concrete shall develop a compressive strength of 4000 psi [28 MPa] in 28 days as determined by test cylinders made in accordance with ASTM C31 and tested in accordance with ASTM C39. The concrete shall contain not less than 470 pounds of cementitious material per cubic yard (280 kg per cubic meter). The water cementitious ratio shall not exceed 0.45 by weight. The air content of the concrete shall be 5% +/- 1.2% as determined by ASTM C231 and shall have a slump of not more than 4 inches (100 mm) as determined by ASTM C143.

610-3.3 Mixing. Concrete may be mixed at the construction site, at a central point, or wholly or in part in truck mixers. The concrete shall be mixed and delivered in accordance with the requirements of ASTM C94 or ASTM C685.

The concrete shall be mixed only in quantities required for immediate use. Concrete shall not be mixed while the air temperature is below 40° F (4° C) without the Construction Manager's approval. If approval is granted for mixing under such conditions, aggregates or water, or both, shall be heated and the concrete shall be placed at a temperature not less than 50°F (10° C) nor more than 100° F (38° C). The Contractor shall be held responsible for any defective work, resulting from freezing or injury in any manner during placing and curing, and shall replace such work at his expense.

Retempering of concrete by adding water or any other material is not permitted.

The rate of delivery of concrete to the job shall be sufficient to allow uninterrupted placement of the concrete.

610-3.4 Forms. Concrete shall not be placed until all the forms and reinforcements have been inspected and approved by the Construction Manager. Forms shall be of suitable material and shall be of the type, size, shape, quality, and strength to build the structure as shown on the plans. The forms shall be true to line and grade and shall be mortar-tight and sufficiently rigid to prevent displacement and sagging between

supports. The surfaces of forms shall be smooth and free from irregularities, dents, sags, and holes. The Contractor shall be responsible for their adequacy.

The internal form ties shall be arranged so no metal will show in the concrete surface or discolor the surface when exposed to weathering when the forms are removed. All forms shall be wetted with water or with a non-staining mineral oil, which shall be applied immediately before the concrete is placed. Forms shall be constructed so they can be removed without injuring the concrete or concrete surface.

610-3.5 Placing Reinforcement. All reinforcement shall be accurately placed, as shown on the plans, and shall be firmly held in position during concrete placement. Bars shall be fastened together at intersections. The reinforcement shall be supported by approved metal chairs. Shop drawings, lists, and bending details shall be supplied by the Contractor when required.

610-3.6 Embedded Items. Before placing concrete, all embedded items shall be firmly and securely fastened in place as indicated. All embedded items shall be clean and free from coating, rust, scale, oil, or any foreign matter. The concrete shall be spaded and consolidated around and against embedded items. The embedding of wood shall not be allowed.

610-3.7 Concrete Consistency. The Contractor shall monitor the consistency of the concrete delivered to the project site; collect each batch ticket; check temperature; and perform slump tests on each truck at the project site in accordance with ASTM C143.

610-3.8 Placing Concrete. All concrete shall be placed during daylight hours, unless otherwise approved. The concrete shall not be placed until the depth and condition of foundations, the adequacy of forms and falsework, and the placing of the steel reinforcing have been approved by the Construction Manager. Concrete shall be placed as soon as practical after mixing, but in no case later than one (1) hour after water has been added to the mix. The method and manner of placing shall avoid segregation and displacement of the reinforcement. Troughs, pipes, and chutes shall be used as an aid in placing concrete when necessary. The concrete shall not be dropped from a height of more than 5 feet (1.5 m). Concrete shall be deposited as nearly as practical in its final position to avoid segregation due to rehandling or flowing. Do not subject concrete to procedures which cause segregation. Concrete shall be placed on clean, damp surfaces, free from running water, or on a properly consolidated soil foundation.

610-3.9 Vibration. Vibration shall follow the guidelines in American Concrete Institute (ACI) Committee 309R, Guide for Consolidation of Concrete.

610-3.10 Joints. Joints shall be constructed as indicated on the plans.

610-3.11 Finishing. All exposed concrete surfaces shall be true, smooth, and free from open or rough areas, depressions, or projections. All concrete horizontal plane surfaces shall be brought flush to the proper elevation with the finished top surface struck-off with a straightedge and floated.

610-3.12 Curing Protection. All concrete shall be properly cured in accordance with the recommendations in American Concrete Institute (ACI) 308R, Guide to External Curing of Concrete. The concrete shall be protected from damage until project acceptance.

610-3.13 Cold Weather Placement. When concrete is placed at temperatures below 40°F (4°C), follow the cold weather concreting recommendations found in ACI 306R, Cold Weather Concreting.

610-3.14 Hot Weather Placement. When concrete is placed in hot weather greater than 85°F (30 °C), follow the hot weather concreting recommendations found in ACI 305R, Hot Weather Concreting.

QUALITY ASSURANCE (QA)

610-4.1 Quality Insurance Testing. Concrete for each day's placement will be accepted on the basis of the compressive strength specified in paragraph 610-3.2. The Construction Manager will sample the concrete in accordance with ASTM C172; test the slump in accordance with ASTM C143; test air content in accordance with ASTM C231; make and cure compressive strength specimens in accordance with ASTM C31; and test in accordance with ASTM C39. The QA testing agency will meet the requirements of ASTM C1077.

The Contractor shall provide adequate facilities for the curing of cylinders.

610-4.2 Defective Work. Any defective work that cannot be satisfactorily repaired as determined by the Construction Manager, shall be removed and replaced at the Contractor's expense. Defective work includes, but is not limited to, uneven dimensions, honeycombing and other voids on the surface or edges of the concrete.

METHOD OF MEASUREMENT

610-5.1 Unless otherwise outlined below, concrete shall be considered incidental and no separate measurement shall be made.

BASIS OF PAYMENT

610-6.1 Concrete shall be considered incidental and no separate payment shall be made.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM A184	Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A704	Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
ASTM A706	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A775	Standard Specification for Epoxy-Coated Steel Reinforcing Bars

ASTM A884	Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement	
ASTM A934	Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars	
ASTM A1064	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete	
ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field	
ASTM C33	Standard Specification for Concrete Aggregates	
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens	
ASTM C94	Standard Specification for Ready-Mixed Concrete	
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates	
ASTM C114	Standard Test Methods for Chemical Analysis of Hydraulic Cement	
ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates	
ASTM C143	Standard Test Method for Slump of Hydraulic-Cement Concrete	
ASTM C150	Standard Specification for Portland Cement	
ASTM C171	Standard Specification for Sheet Materials for Curing Concrete	
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete	
ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method	
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete	
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete	
ASTM C311	Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete	
ASTM C494	Standard Specification for Chemical Admixtures for Concrete	
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete	
ASTM C666	Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing	

ASTM C685	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1017	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1077	Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1157	Standard Performance Specification for Hydraulic Cement
ASTM C1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1365	Standard Test Method for Determination of the Proportion of Phases in Portland Cement and Portland-Cement Clinker Using X-Ray Powder Diffraction Analysis
ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Asphalt Types)
ASTM D1752	Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction

American Concrete Institute (ACI)

ACI 305R	Hot Weather Concreting
ACI 306R	Cold Weather Concreting
ACI 308R	Guide to External Curing of Concrete
ACI 309R	Guide for Consolidation of Concrete

END OF ITEM P-610
ITEM P-620 RUNWAY AND TAXIWAY MARKING

DESCRIPTION

620-1.1 This item shall consist of the preparation and painting of numbers, markings, and stripes on the surface of runways, taxiways, and aprons, in accordance with these specifications and at the locations shown on the plans, or as directed by the Construction Manager. The terms "paint" and "marking material" as well as "painting" and "application of markings" are interchangeable throughout this specification.

MATERIALS

620-2.1 Materials acceptance. The Contractor shall furnish manufacturer's certified test reports, for materials shipped to the project. The certified test reports shall include a statement that the materials meet the specification requirements. This certification along with a copy of the paint manufacturer's surface preparation; marking materials, including adhesion, flow promoting and/or floatation additive; and application requirements must be submitted and approved by the Construction Manager prior to the initial application of markings. The reports can be used for material acceptance or the Construction Manager may perform verification testing. The reports shall not be interpreted as a basis for payment. The Contractor shall notify the Construction Manager upon arrival of a shipment of materials to the site. All material shall arrive in sealed containers that are easily quantifiable for inspection by the Construction Manager.

610-2.2 Marking materials.

Paint ¹				Glass Beads ²	
Туре	Color	Fed Std. 595 Number	Application Rate Maximum ³	Туре	Application Rate
III	White	37925	$55 \text{ ft}^2/\text{gal} (2.8 \text{ m}^2/\text{l})$	Ι	7 lb/gal (0.85 kg/l)
III	Yellow	33538	55 ft ² /gal (2.8 m ² /l)	III	8 lb/gal (1.0 kg/l)
III	Black	37038	55 ft ² /gal (2.8 m ² /l)	N/A	N/A

 Table 1. Marking Materials

¹ See paragraph 620-2.2a

² See paragraph 620-2.2b

³ Application rate shall provide a minimum thickness of 15 mils or per manufacturer's recommendation; Contractor to increase application rate to achieve a thickness of 15 mils if necessary. In no case will an application rate lower than those shown in table 1 be allowed.

Taxiway edge stripe shall not have beads applied.

a. Paint. Paint shall be waterborne or preformed thermoplastic in accordance with the requirements of this paragraph. Paint colors shall comply with Federal Standard No. 595.

Waterborne. Paint shall meet the requirements of Federal Specification TT-P-1952F, Type III. The non-volatile portion of the vehicle for all paint types shall be composed of a 100% acrylic polymer as determined by infrared spectral analysis. The acrylic resin used for Type III shall be 100% cross linking acrylic as evidenced by infrared peaks at wavelengths 1568, 1624, and 1672 cm-l with intensities equal to those produced by an acrylic resin known to be 100% cross linking.

Preformed Thermoplastic Airport Pavement Markings. Markings must be composed of ester modified resins in conjunction with aggregates, pigments, and binders that have been factory produced as a finished product. The material must be impervious to degradation by aviation fuels, motor fuels, and lubricants.

(1) The markings must be able to be applied in temperatures as low as 35°F without any special storage, preheating, or treatment of the material before application.

(a) The markings must be supplied with an integral, non-reflectorized black border.

(2) Graded glass beads.

(a) The material must contain a minimum of 30% intermixed graded glass beads by weight. The intermixed beads shall conform to Federal Specification TT-B-1325D, Type I, gradation A and Federal Specification TT-B-1325D, Type IV.

(b) The material must have factory applied coated surface beads in addition to the intermixed beads at a rate of one (1) lb $(0.45 \text{ kg}) (\pm 10\%)$ per 10 square feet (1 sq m). These factory-applied coated surface beads shall have a minimum of 90% true spheres, minimum refractive index of 1.50, and meet the following gradation.

Size Gradation		Detained 0/	Dessing 0/
U.S. Mesh	μm	Retained, 76	Passing, 70
12	1700	0 - 2	98 - 100
14	1400	0 - 3.5	96.5 - 100
16	1180	2 - 25	75 - 98
18	1000	28 - 63	37 - 72
20	850	63 - 72	28 - 37
30	600	67 - 77	23 - 33
50	300	89 - 95	5 - 11
80	200	97 - 100	0 - 3

Preformed Thermoplastic Bead Gradation

(3) Heating indicators. The material manufacturer shall provide a method to indicate that the material has achieved satisfactory adhesion and proper bead embedment during application and that the installation procedures have been followed.

(4) Pigments. Percent by weight.

(a) White:

• Titanium Dioxide, ASTM D476, type II shall be 10% minimum.

(b) Yellow and Colors:

- Titanium Dioxide, ASTM D476, type II shall be 1% minimum.
- Organic yellow, other colors, and tinting as required to meet color standard.

(5) Prohibited materials. The manufacturer shall certify that the product does not contain mercury, lead, hexavalent chromium, halogenated solvents, nor any carcinogen as defined in 29 CFR 1910.1200 in amounts exceeding permissible limits as specified in relevant federal regulations.

(6) Daylight directional reflectance.

(a) White: The daylight directional reflectance of the white paint shall not be less than 75% (relative to magnesium oxide), when tested in accordance with ASTM E2302.

(b) Yellow: The daylight directional reflectance of the yellow paint shall not be less than 45% (relative to magnesium oxide), when tested in accordance with ASTM E2302. The x and y values shall be consistent with the federal Hegman yellow color standard chart for traffic yellow standard 33538, or shall be consistent with the tolerance listed below:

1.	x .462	2.	x .470	3.	x .479	4.	x .501
5.	y .438	6.	y .455	7.	y .428	8.	y .452

(7) Skid resistance. The surface, with properly applied and embedded surface beads, must provide a minimum resistance value of 45 BPN when tested according to ASTM E303.

(8) Thickness. The material must be supplied at a nominal thickness of 65 mil (1.7 mm).

(9) Environmental resistance. The material must be resistant to deterioration due to exposure to sunlight, water, salt, or adverse weather conditions and impervious to aviation fuels, gasoline, and oil.

(10) Retroreflectivity. The material, when applied in accordance with manufacturer's guidelines, must demonstrate a uniform level of nighttime retroreflection when tested in accordance to ASTM E1710.

(11) Packaging. Packaging shall protect the material from environmental conditions until installation.

$\left(12\right)$ Preformed thermoplastic airport pavement marking requirements.

(a) The markings must be a resilient thermoplastic product with uniformly distributed glass beads throughout the entire cross-sectional area. The markings must be resistant to the detrimental effects of aviation fuels, motor fuels and lubricants, hydraulic fluids, deicers, antiicers, protective coatings, etc. Lines, legends, and symbols must be capable of being affixed to asphalt and/or Portland cement concrete pavements by the use of a large radiant heater. Colors shall be available as required.

(b) The markings must be capable of conforming to pavement contours, breaks, and faults through the action of airport traffic at normal pavement temperatures. The markings must be capable of fully conforming to grooved pavements, including pavement grooving per advisory circular (AC) 150/5320-12, current version. The markings shall have resealing characteristics, such that it is capable of fusing with itself and previously applied thermoplastics when heated with a heat source per manufacturer's recommendation.

(c) Multicolored markings must consist of interconnected individual pieces of preformed thermoplastic pavement marking material, which through a variety of colors and patterns, make up the desired design. The individual pieces in each large marking segment (typically more than 20 feet (6 m) long) must be factory assembled with a compatible material and interconnected so that in the field it is not necessary to assemble the individual pieces within a marking segment. Obtaining multicolored effect by overlaying materials of different colors is not acceptable due to resulting inconsistent marking thickness and inconsistent application temperature in the marking/substrate interface.

(d) The marking material must set up rapidly, permitting the access route to be reopened to traffic after application.

(e) The marking material shall have an integral color throughout the thickness of the marking material.

b. Reflective media. Glass beads for white and yellow paint shall meet the requirements for Federal Specification TT-B-1325D Type I, Gradation A.

Glass beads shall be treated with all compatible coupling agents recommended by the manufacturers of the paint and reflective media to ensure adhesion and embedment.

Glass beads shall not be used in black and green paint.

CONSTRUCTION METHODS

620-3.1 Weather limitations. Painting shall only be performed when the surface is dry, and the ambient temperature and the pavement surface temperature meet the manufacturer's recommendations in accordance with paragraph 620-2.1. Painting operations shall be discontinued when the ambient or surface temperatures does not meet the manufacturer's recommendations. Markings shall not be applied when the wind speed exceeds 10 mph unless windscreens are used to shroud the material guns. Markings shall not be applied when weather conditions are forecasts to not be within the manufacturers' recommendations for application and dry time.

620-3.2 Equipment. Equipment shall include the apparatus necessary to properly clean the existing surface, a mechanical marking machine, a bead dispensing machine, and such auxiliary hand-painting equipment as may be necessary to satisfactorily complete the job.

The mechanical marker shall be an atomizing spray-type or airless type marking machine with automatic glass bead dispensers suitable for application of traffic paint. It shall produce an even and uniform film thickness and appearance of both paint and glass beads at the required coverage and shall apply markings of uniform cross-sections and clear-cut edges without running or spattering and without over spray. The marking equipment for both paint and beads shall be calibrated daily.

620-3.3 Preparation of surfaces. Immediately before application of the paint, the surface shall be dry and free from dirt, grease, oil, laitance, or other contaminates that would reduce the bond between the paint and the pavement. Use of any chemicals or impact abrasives during surface preparation shall be approved in advance by the Engineer. After the cleaning operations, sweeping, blowing, or rinsing with pressurized water shall be performed to ensure the surface is clean and free of grit or other debris left from the cleaning process.

Cleaning and removal operation shall not cause damage to the exist pavement surface or joint sealant. Any damage resulting from cleaning operation shall be repaired at no additional cost to the owner.

a. Preparation of new pavement surfaces. The area to be painted shall be cleaned by broom, blower, water blasting, or by other methods approved by the Engineer to remove all contaminants, including PCC curing compounds, minimizing damage to the pavement surface.

b. Preparation of pavement to remove existing markings. Existing pavement markings shall be removed by rotary grinding, water blasting, or by other methods approved by the Engineer minimizing damage to the pavement surface. The removal area may need to be larger than the area of the markings to eliminate ghost markings. After removal of markings on asphalt pavements, apply a fog seal or seal coat to 'block out' the removal area to eliminate 'ghost' markings.

c. Preparation of pavement markings prior to remarking. Prior to remarking existing markings, loose existing markings must be removed minimizing damage to the pavement surface, with a method approved by the Construction Manager. After removal, the surface shall be cleaned of all residue or debris.

Prior to the application of markings, the Contractor shall certify in writing that the surface is dry and free from dirt, grease, oil, laitance, or other foreign material that would prevent the bond of the paint to the pavement or existing markings. This certification along with a copy of the paint manufactures application and surface preparation requirements must be submitted to the Construction Manager prior to the initial application of markings.

620-3.4 Layout of markings. The proposed markings shall be laid out in advance of the paint application. The locations of markings to receive glass beads shall be shown on the plans.

620-3.5 Application. A period of 30 days shall elapse between placement of surface course or seal coat and application of the permanent paint markings. Paint shall be applied at the locations and to the dimensions and spacing shown on the plans. Paint shall not be applied until the layout and condition of the surface has been approved by the Construction Manager.

The edges of the markings shall not vary from a straight line more than 1/2 inch (12 mm) in 50 feet (15 m), and marking dimensions and spacing shall be within the following tolerances:

Dimension and Spacing	Tolerance
36 inch (910 mm) or less	$\pm 1/2$ inch (12 mm)
greater than 36 inch to 6 feet (910 mm to 1.85 m)	±1 inch (25 mm)
greater than 6 feet to 60 feet (1.85 m to 18.3 m)	±2 inch (50 mm)
greater than 60 feet (18.3 m)	±3 inch (76 mm)

Marking Dimensions and Spacing Tolerance

The paint shall be mixed in accordance with the manufacturer's instructions and applied to the pavement with a marking machine at the rate shown in Table 1. The addition of thinner will not be permitted.

Glass beads shall be distributed upon the marked areas at the locations shown on the plans to receive glass beads immediately after application of the paint. A dispenser shall be furnished that is properly designed for attachment to the marking machine and suitable for dispensing glass beads. Glass beads shall be applied at the rate shown in Table 1. Glass beads shall not be applied to black paint or green paint. Glass beads shall adhere to the cured paint or all marking operations shall cease until corrections are made. Different bead types shall not be mixed. Regular monitoring of glass bead embedment and distribution should be performed.

620-3.6 Application of preformed thermoplastic airport pavement markings. Contractor to supply Owner all thermoplastic material for Owner's installation. Contractor shall coordinate with the Construction Manager for the Owner installation of thermoplastic material. Contractor shall supply ample time for Owner installation of thermoplastic without impacting contractors schedule.

Contractor shall prepare all areas for thermoplastic application immediately prior to Owners installation. The pavement shall be clean, dry, and free of debris. A non-volatile organic content (non-VOC) sealer with a maximum applied viscosity of 250 centiPoise must be applied to the pavement shortly before the markings are applied. The supplier must enclose application instructions with each box/package.

620-3.7 Control strip. Prior to the full application of airfield markings, the Contractor shall prepare a control strip in the presence of the Construction Manager. The Contractor shall demonstrate the surface preparation method and all striping equipment to be used on the project. The marking equipment must achieve the prescribed application rate of paint and population of glass beads (per Table 1) that are properly embedded and evenly distributed across the full width of the marking. Prior to acceptance of the control strip, markings must be evaluated during darkness to ensure a uniform appearance.

620-3.8 Retro-reflectance. Reflectance shall be measured with a portable retro-reflectometer meeting ASTM E1710 (or equivalent), on a daily basis. A total of 6 reading shall be taken over a 6 square foot area with 3 readings taken from each direction. The average shall be equal to or above the minimum levels of all readings which are within 30% of each other.

Material	Retro-reflectance mcd/m ² /lux			
	White	Yellow	Red	
Initial Type I	300	175	35	
Initial Type III	600	300	35	
Initial Thermoplastic	225	100	35	
All materials, remark when less than ¹	100	75	10	

Minimum Retro-Reflectance Values

¹ 'Prior to remarking determine if removal of contaminants on markings will restore retro-reflectance

620-3.9 Protection and cleanup. After application of the markings, all markings shall be protected from damage until dry. All surfaces shall be protected from excess moisture and/or rain and from disfiguration by spatter, splashes, spillage, or drippings. The Contractor shall remove from the work area all debris, waste, loose reflective media, and by-products generated by the surface preparation and application operations to the satisfaction of the Construction Manager. The Contractor shall dispose of these wastes in strict compliance with all applicable state, local, and federal environmental statutes and regulations.

620-3.10 Quality Control. On a daily basis, Contractor shall supply bead and paint measurements to the Construction Manager. Both bead and paint measurements shall consist of a test card measurement and application rate calculations of paint and/or beads actually applied. Any areas not within application rates shall be reapplied at no additional cost to the Owner.

METHOD OF MEASUREMENT

620-4.1 The quantity of markings to be paid for will be measured by the square foot for the pavement markings indicated in the plans. The area to be paid for will be calculated on the basis of the dimensions shown of the Plans adjusted by the amount of any change ordered by the Owner.

620-4.2 The quantity of temporary markings to be paid for shall be the number of square feet (square meters) of painting performed in accordance with the specifications and accepted by the Construction Manager.

620-4.3 The quantity of thermoplastic surface painted sign markings and taxiway directional markings to be paid for shall be the each of preformed markings ordered, delivered to the Owner, and area prepared for placement by the Owner.

620-4.4 The quantity of thermoplastic non-movement area boundary markings to be paid shall be by the linear foot (meter) of preformed markings ordered, delivered to the Owner, and area prepared for placement by the Owner.

BASIS OF PAYMENT

620-5.1 The price for pavement markings shall be made at the contract unit price for the number of square feet (square meter) placed and shall be full compensation for furnishing all materials and for all labor, equipment, tools, and incidentals necessary to complete the item complete in place and accepted by the Construction Manager in accordance with these specifications.

620-5.2 Payment for non-movement area boundary marking preformed thermoplastic markings shall be made at the contract price per linear foot (meter) of preformed markings. This price shall be full compensation for furnishing all materials and delivery to the Owner as well as surface preparation of installation areas. Contractor installation is not included with this item; installation will be completed by the Owner.

620-5.3 Payment for triangular ramp and taxiway directional preformed thermoplastic markings shall be made at the contract price per each of preformed markings. This price shall be full compensation for furnishing all materials and delivery to the Owner as well as surface preparation of installation areas. Contractor installation is not included with this item; installation will be completed by the Owner.

Payment will be made under:

Item P-620-1	Airfield Striping Removal – per square foot (square meter)
Item P-620-2	Airfield Striping Removal (Contingent) – per square foot (square meter)
Item P-620-3	Airfield Thermoplastic Removal – per square foot (square meter)

Item P-620-4	Airfield Striping Cleaning – per square foot (square meter)
Item P-620-5	Permanent Reflective Airfield Pavement Markings - per square foot (square meter)
Item P-620-6	Miscellaneous Permanent Reflective Airfield Pavement Markings (Contingent) – per square foot (square meter)
Item P-620-7	Permanent Non-Reflective Airfield Pavement Markings – per square foot (square meter)
Item P-620-8	Miscellaneous Permanent Non-Reflective Airfield Pavement Markings (Contingent) – per square foot (square meter)
Item P-620-9	Thermoplastic Runway Holding Position Surface Painted Sign – per each
Item P-620-10	Thermoplastic Taxiway Directional Marking – per each
Item P-620-11	Thermoplastic Runway Holding Position Marking – per linear foot

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM D476	Standard Classification for Dry Pigmentary Titanium Dioxide Products
ASTM D968	Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive
ASTM D1652	Standard Test Method for Epoxy Content of Epoxy Resins
ASTM D2074	Standard Test Method for Total, Primary, Secondary, and Tertiary Amine Values of Fatty Amines by Alternative Indicator Method
ASTM D2240	Standard Test Method for Rubber Property - Durometer Hardness
ASTM D7585	Standard Practice for Evaluating Retroreflective Pavement Markings Using Portable Hand-Operated Instruments
ASTM E303	Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester
ASTM E1710	Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer

	ASTM E2302	Standard Test Method for Measurement of the Luminance Coefficient
		Under Diffuse Illumination of Pavement Marking Materials Using a Portable Reflectometer
	ASTM G154	Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials
Code of	f Federal Regulations (C	CFR)
	40 CFR	Part60,AppendixA-7,Method24Determination of volatile matter content, water content, density, volumesolids, and weight solids of surface coatings
	29 CFR Part 1910.1200) Hazard Communication
Federal	Specifications (FED SH	PEC)
	FED SPEC TT-B-1325	D Beads (Glass Spheres) Retro-Reflective
	FED SPEC TT-P-1952	F Paint, Traffic and Airfield Marking, Waterborne
	FED STD 595	Colors used in Government Procurement
Comme	ercial Item Description	
	A-A-2886B	Paint, Traffic, Solvent Based
Advisor	ry Circulars (AC)	
	AC 150/5340-1	Standards for Airport Markings
	AC 150/5320-12	Measurement, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces

END OF ITEM P-620

Item P-621 Saw-Cut Grooves

DESCRIPTION

621-1.1 This item consists of constructing saw-cut grooves to minimize hydroplaning during wet weather, providing a skid resistant surface in accordance with these specifications and at the locations shown on the plans, or as directed by the Engineer.

CONSTRUCTION METHODS

621-2.1 Procedures. The Contractor shall submit to the Construction Manager the grooving sequence and method of placing guide lines to control grooving operation. Transverse grooves saw-cut in the pavement must form a 1/4 inch (\pm 1/16 inch, -0 inch) wide by 1/4 inch (\pm 1/16 inch) deep by 1-1/2 inch (\pm 1/8 inch, \pm 0 inch) center-to-center configuration. The grooves must be continuous for the entire runway length. They must be saw-cut transversely (perpendicular to centerline) in the runway and high-speed taxiway pavement to not less than 10 feet (3 m) from the runway pavement edge to allow adequate space for equipment operation.

The saw-cut grooves must meet the following tolerances. The tolerances apply to each day's production and to each piece of grooving equipment used for production. The Contractor is responsible for all controls and process adjustments necessary to meet these tolerances. The Contractor shall routinely spot check for compliance each time the equipment aligns for a grooving pass.

a. Alignment tolerance. The grooves shall not vary more than $\pm 1-1/2$ inch (38 mm) in alignment for 75 feet (23 m) along the runway length, allowing for realignment every 500 feet (150 m) along the runway length.

b. Groove tolerance.

(1) Depth. The standard depth is 1/4 inch (6 mm). At least 90% of the grooves must be at least 3/16 inch (5 mm), at least 60% of the grooves must be at least 1/4 inch (6 mm), and not more than 10% of the grooves may exceed 5/16 inch (8 mm).

(2) Width. The standard width is 1/4 inch (6 mm). At least 90% of the grooves must be at least 3/16 inch (5 mm), at least 60% of the grooves must be at least 1/4 inch (6 mm), and not more than 10% of the grooves may exceed 5/16 inch (8 mm).

(3) Center-to-center spacing. The standard spacing is 1-1/2 inch (38 mm). Minimum spacing 1-3/8 inch (34 mm). Maximum spacing 1-1/2 inch (38 mm).

Saw-cut grooves must not be closer than 3 inches (8 cm) or more than 9 inches (23 cm) from transverse joints in concrete pavements. Grooves must not be closer than 6 inches (150 mm) and no more than 18 inches (0.5 m) from in-pavement light fixtures. Grooves may be continued through longitudinal construction joints. Where neoprene compression seals have been installed and the compression seals are recessed sufficiently to prevent damage from the grooving operation, grooves may be continued through the longitudinal joints. Where neoprene compression seals have been installed and the compression seals are not recessed sufficiently to prevent damage from the grooving operation, grooves must not be closer than 3 inches (8 cm) or more than 5 inches (125 mm) from the longitudinal joints. Where lighting cables are installed, grooving through longitudinal or diagonal saw kerfs shall not be allowed.

621-2.2 Environmental requirements. Grooving operations will not be permitted when freezing conditions prevent the immediate removal of debris and/or drainage of water from the grooved area. Discharge and disposal of waste slurry shall be the Contractor's responsibility.

621-2.3 Control strip. Groove a control strip in an area of the pavement outside of the trafficked area, as approved by the Engineer. The area shall be **50** feet long by two lanes wide. Demonstrate the setup and alignment process, the grooving operation, and the waste slurry disposal.

621-2.4 Existing pavements. Bumps, depressed areas, bad or faulted joints, and badly cracked and/or spalled areas in the pavement shall not be grooved until such areas are adequately repaired or replaced. **621-2.5 New pavements.** New asphalt and Portland cement concrete pavements shall be allowed to cure for a minimum of 30 days before grooving, to allow the material to become stable enough to prevent closing of the grooves under normal use. All grade corrections must be completed prior to grooving. Spalling along or tearing or raveling of the groove edges shall not be allowed.

621-2.6 Grooving machine. Provide a grooving machine that is power driven, self-propelled, specifically designed and manufactured for pavement grooving, and has a self-contained and integrated continuous slurry vacuum system as the primary method for removing waste slurry. The grooving machine shall be equipped with diamond-saw cutting blades, and capable of making at least 18 inches (0.5 m) in width of multiple parallel grooves in one pass of the machine. Thickness of the cutting blades shall be capable of making the required width and depth of grooves in one pass of the machine. The cutting head shall not contain a mixture of new and worn blades or blades of unequal wear or diameter. Match the blade type and configuration with the hardness of the existing airfield pavement. The wheels on the grooving machine shall be of a design that will not scar or spall the pavement. Provide the machine with devices to control depth of groove and alignment.

621-2.7 Water supply. Water for the grooving operation shall be provided by the Contractor. **621-2.8 Clean-up.** During and after installation of saw-cut grooves, the Contractor must remove from the pavement all debris, waste, and by-products generated by the operations to the satisfaction of the Construction Manager. Cleanup of waste material must be continuous during the grooving operation. Flush debris produced by the machine to the edge of the grooved area or pick it up as it forms. The dust coating remaining shall be picked up or flushed to the edge of the area if the resultant accumulation is not detrimental to the vegetation or storm drainage system. Accomplish all flushing operations in a manner to prevent erosion on the shoulders or damage to vegetation. Waste material must be disposed of in an approved manner. Waste material must not be allowed to enter the airport storm sewer system. The Contractor must dispose of these wastes in strict compliance with all applicable state, local, and federal environmental statutes and regulations

621-2.9 Repair of damaged pavement. Grooving must be stopped and damaged pavement repaired at the Contractor's expense when directed by the Construction Manager.

ACCEPTANCE

621-3.1 Acceptance testing. Grooves will be accepted based on results of zone testing. All acceptance testing necessary to determine conformance with the groove tolerances specified will be performed by the Construction Manager.

Instruments for measuring groove width and depth must have a range of at least 0.5 inch (12 mm) and a resolution of at least 0.005 inch (0.13 mm). Gauge blocks or gauges machined to standard grooves width, depth, and spacing may be used.

Instruments for measuring center-to-center spacing must have a range of at least 3 inches (8 cm) and a resolution of at least 0.02 inch (0.5 mm).

The Construction Manager will measure grooves in five zones across the pavement width. Measurements will be made at least three times during each day's production. Measurements in all zones will be made for each cutting head on each piece of grooving equipment used for each day's production.

The five zones are as follows:

- Zone 1 Centerline to 5 feet (1.5 m) left or right of the centerline.
- Zone 2 5 feet (1.5 m) to 25 feet (7.5 m) left of the centerline.
- Zone 3 5 feet (1.5 m) 25 feet (7.5 m) right of the centerline.
- Zone 4 25 feet (7.5 m) to edge of grooving left of the centerline.
- Zone 5 25 feet (7.5 m) to edge of grooving right of the centerline.

At a random location within each zone, five consecutive grooves sawed by each cutting head on each piece of grooving equipment will be measured for width, depth, and spacing. The five consecutive measurements must be located about the middle blade of each cutting head ± 4 inches (100 mm). Measurements will be made along a line perpendicular to the grooves.

- Width or depth measurements less than 0.170 inch (4 mm) shall be considered less than 3/16 inch (5 mm).
- Width or depth measurements more than 0.330 inch (8 mm) shall be considered more than 5/16 inch (8 mm).
- Width or depth measurements more than 0.235 inch (6 mm) shall be considered more than 1/4 inch (6 mm).

Production must be adjusted when more than one groove on a cutting head fails to meet the standard depth, width, or spacing in more than one zone.

METHOD OF MEASUREMENT

621-4.1 The quantity of grooving to be paid for shall be the number of square yards (square meters) of grooving performed in accordance with the specifications and accepted by the Construction Manager per paragraph 621-3.1.

BASIS OF PAYMENT

621-5.1 Payment for saw-cut grooving. Payment for saw-cut grooving will be made at the contract unit price per square yard (square meter) for saw-cut grooving. This price shall be full compensation for furnishing all materials, and for all preparation, delivering, and application of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-621-5.1 Grooving, unit price per square yard (square meter)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Advisory Circulars (AC)

AC 150/5320-12

Measurement, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces

END OF ITEM P-621

ITEM F-162 CHAIN-LINK FENCE

DESCRIPTION

162-1.1 This item shall consist of furnishing and erecting a chain-link fence in accordance with these specifications, the details shown on the plans, and in conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

162-2.1 Fabric. The fabric shall be woven with a 9-gauge galvanized steel wire in a 2-inch (50 mm) mesh and shall meet the requirements of ASTM A392, Class 2.

162-2.2 Barbed wire. Barbed wire shall be 2-strand 12-1/2 gauge zinc-coated wire with 4-point barbs and shall conform to the requirements of ASTM A121, Class 3, Chain Link Fence Grade.

162-2.3 Posts, rails, and braces. Line posts, rails, and braces shall conform to the requirements of ASTM F1043 or ASTM F1083 as follows:

- Galvanized tubular steel pipe shall conform to the requirements of Group IA, (Schedule 40) coatings conforming to Type A, or Group IC (High Strength Pipe), External coating Type B, and internal coating Type B or D.
- Roll Formed Steel Shapes (C-Sections) shall conform to the requirements of Group IIA, and be galvanized in accordance with the requirements of ASTM F1043, Type A.
- Hot-Rolled Shapes (H Beams) shall meet the requirements of Group III, and be galvanized in accordance with the requirements of ASTM F1043, Type A.
- Aluminum Pipe shall conform to the requirements of Group IB.
- Aluminum Shapes shall conform to the requirements of Group IIB.
- Vinyl or polyester coated steel shall conform to the requirements of ASTM F1043, Paragraph 7.3, Optional Supplemental Color Coating.
- Composite posts shall conform to the strength requirements of ASTM F1043 or ASTM F1083. The strength loss of composite posts shall not exceed 10% when subjected to 3,600 hours of exposure to light and water in accordance with ASTM G152, ASTM G153, ASTM G154, and ASTM G155.
- Posts, rails, and braces furnished for use in conjunction with aluminum alloy fabric shall be aluminum alloy or composite.

Posts, rails, and braces, with the exception of galvanized steel conforming to ASTM F1043 or ASTM F1083, Group 1A, Type A, or aluminum alloy, shall demonstrate the ability to withstand testing in salt spray in accordance with ASTM B117 as follows:

(1) External: 1,000 hours with a maximum of 5% red rust.

(2) Internal: 650 hours with a maximum of 5% red rust.

The dimensions of the posts, rails, and braces shall be in accordance with Tables I through VI of Federal Specification RR-F-191/3.

162-2.4 Gates. Gate frames shall consist of galvanized steel pipe and shall conform to the specifications for the same material under paragraph 162-2.3. The fabric shall be of the same type material as used in the fence.

162-2.5 Wire ties and tension wires. Wire ties for use in conjunction with a given type of fabric shall be of the same material and coating weight identified with the fabric type. Tension wire shall be 7-gauge marcelled steel wire with the same coating as the fabric type and shall conform to ASTM A824.

All material shall conform to Federal Specification RR-F-191/4.

162-2.6 Miscellaneous fittings and hardware. Miscellaneous steel fittings and hardware for use with zinc-coated steel fabric shall be of commercial grade steel or better quality, wrought or cast as appropriate to the article, and sufficient in strength to provide a balanced design when used in conjunction with fabric posts, and wires of the quality specified herein. All steel fittings and hardware shall be protected with a zinc coating applied in conformance with ASTM A153. Barbed wire support arms shall withstand a load of 250 pounds (113 kg) applied vertically to the outermost end of the arm.

162-2.7 Concrete. Concrete shall have a minimum 28-day compressive strength of 3000 psi (2670 kPa).

162-2.8 Marking. Each roll of fabric shall carry a tag showing the kind of base metal (steel, aluminum, or aluminum alloy number), kind of coating, the gauge of the wire, the length of fencing in the roll, and the name of the manufacturer. Posts, wire, and other fittings shall be identified as to manufacturer, kind of base metal (steel, aluminum, or aluminum alloy number), and kind of coating.

CONSTRUCTION METHODS

162-3.1 General. The fence shall be constructed in accordance with the details on the plans and as specified here using new materials. All work shall be performed in a workmanlike manner satisfactory to the Construction Manager. The Contractor shall layout the fence line based on the plans. The Contractor shall span the opening below the fence with barbed wire at all locations where it is not practical to conform the fence to the general contour of the ground surface because of natural or manmade features such as drainage ditches. The new fence shall be permanently tied to the terminals of existing fences as shown on the plans. The Contractor shall stake down the woven wire fence at several points between posts as shown on the plans.

The Contractor shall arrange the work so that construction of the new fence will immediately follow the removal of existing fences. The length of unfenced section at any time shall not exceed 300 feet (90 m). The work shall progress in this manner and at the close of the working day the newly constructed fence shall be tied to the existing fence.

162-3.2 Clearing fence line. Clearing shall consist of the removal of all stumps, brush, rocks, trees, or other obstructions that will interfere with proper construction of the fence. Stumps within the cleared area of the fence shall be grubbed or excavated. The bottom of the fence shall be placed a uniform distance above ground, as specified in the plans. When shown on the plans or as directed by the Construction

Manager, the existing fences which interfere with the new fence location shall be removed by the Contractor as a part of the construction work unless such removal is listed as a separate item in the bid schedule. All holes remaining after post and stump removal shall be refilled with suitable soil, gravel, or other suitable material and compacted with tampers.

The cost of removing and disposing of the material shall not constitute a pay item and shall be considered incidental to fence construction.

162-3.3 Installing posts. All posts shall be set in concrete at the required dimension and depth and at the spacing shown on the plans.

The concrete shall be thoroughly compacted around the posts by tamping or vibrating and shall have a smooth finish slightly higher than the ground and sloped to drain away from the posts. All posts shall be set plumb and to the required grade and alignment. No materials shall be installed on the posts, nor shall the posts be disturbed in any manner within seven (7) days after the individual post footing is completed.

Should rock be encountered at a depth less than the planned footing depth, a hole 2 inches (50 mm) larger than the greatest dimension of the posts shall be drilled to a depth of 12 inches (300 mm). After the posts are set, the remainder of the drilled hole shall be filled with grout, composed of one part Portland cement and two parts mortar sand. Any remaining space above the rock shall be filled with concrete in the manner described above.

In lieu of drilling, the rock may be excavated to the required footing depth. No extra compensation shall be made for rock excavation.

162-3.4 Installing top rails. The top rail shall be continuous and shall pass through the post tops. The coupling used to join the top rail lengths shall allow for expansion.

162-3.5 Installing braces. Horizontal brace rails, with diagonal truss rods and turnbuckles, shall be installed at all terminal posts.

162-3.6 Installing fabric. The wire fabric shall be firmly attached to the posts and braced as shown on the plans. All wire shall be stretched taut and shall be installed to the required elevations. The fence shall generally follow the contour of the ground, with the bottom of the fence fabric no less than one inch (25 mm) or more than 4 inches (100 mm) from the ground surface. Grading shall be performed where necessary to provide a neat appearance.

At locations of small natural swales or drainage ditches and where it is not practical to have the fence conform to the general contour of the ground surface, longer posts may be used and multiple strands of barbed wire stretched to span the opening below the fence. The vertical clearance between strands of barbed wire shall be 6 inches (150 mm) or less.

162-3.7 Electrical grounds. Electrical grounds shall be constructed at 500 feet (150 m) intervals. The ground shall be accomplished with a copper clad rod 8 feet (2.4 m) long and a minimum of 5/8 inches (16 mm) in diameter driven vertically until the top is 6 inches (150 mm) below the ground surface. A No. 6 solid copper conductor shall be clamped to the rod and to the fence in such a manner that each element of the fence is grounded. Installation of ground rods shall not constitute a pay item and shall be considered incidental to fence construction. The Contractor shall comply with FAA-STD-019, Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment, paragraph 4.2.3.8, Lightning Protection for Fences and Gates, when fencing is adjacent to FAA facilities.

162-3.8 Cleaning up. The Contractor shall remove from the vicinity of the completed work all tools, buildings, equipment, etc., used during construction. All disturbed areas shall be seeded per T-901.

METHOD OF MEASUREMENT

162-4.1 Fencing and temporary gates will not be measured and shall be considered incidental to airport safety and security or other items of work.

BASIS OF PAYMENT

162-5.1 There shall be no direct payment for fencing or temporary gates.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM A121	Standard Specification for Metallic-Coated Carbon Steel Barbed Wire
ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A392	Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
ASTM A491	Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric
ASTM A824	Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence
ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM F668	Standard Specification for Polyvinyl Chloride (PVC), Polyolefin and other Organic Polymer Coated Steel Chain-Link Fence Fabric
ASTM F1043	Standard Specification for Strength and Protective Coatings on Steel Industrial Fence Framework
ASTM F1083	Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
ASTM F1183	Standard Specification for Aluminum Alloy Chain Link Fence Fabric
ASTM F1345	Standard Specification for Zinc 5% Aluminum-Mischmetal Alloy Coated Steel Chain-Link Fence Fabric
ASTM G152	Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
ASTM G153	Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

ASTM G154	Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials
ASTM G155	Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials
Federal Specifications (FED SP	EC)
FED SPEC RR-F-191/3	Fencing, Wire and Post, Metal (Chain-Link Fence Posts, Top Rails and Braces)
FED SPEC RR-F-191/4	Fencing, Wire and Post, Metal (Chain-Link Fence Accessories)
FAA Standard	
FAA-STD-019	Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment
FAA Orders	
5300.38	AIP Handbook

END OF ITEM F-162

ITEM D-701 PIPE FOR STORM DRAINS AND CULVERTS

DESCRIPTION

701-1.1 This item shall consist of the construction of pipe culverts and storm drains in accordance with these specifications and in reasonably close conformity with the lines and grades shown on the plans.

MATERIALS

701-2.1 Materials shall meet the requirements shown on the plans and specified below. Underground piping and components used in drainage systems for terminal and aircraft fueling ramp drainage shall be noncombustible and inert to fuel in accordance with National Fire Protection Association (NFPA) 415.

701-2.2 Pipe. The pipe shall be of the type called for on the plans or in the proposal and shall be in accordance with the following appropriate requirements:

AASHTO R73	Standard Practice for Evaluation of Precast Concrete Drainage Productions
ASTM C14	Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C76	Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C506	Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
ASTM C507	Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
ASTM C655	Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
ASTM C1433	Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM C1479	Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations
ASTM C1577	Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers Designed According to AASHTO LRFD
ASTM C1786	Standard Specification for Segmental Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers Designed According to AASHTO LRFD

ASTM C1840 Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain, and Storm Sewer Pipe

701-2.3 Concrete. Concrete for pipe cradles shall have a minimum compressive strength of 2000 psi (13.8 MPa) at 28 days and conform to the requirements of ASTM C94.

701-2.4 Rubber gaskets. Rubber gaskets for rigid pipe shall conform to the requirements of ASTM C443.

701-2.5 Joint mortar. Pipe joint mortar shall consist of one part Portland cement and two parts sand. The Portland cement shall conform to the requirements of ASTM C150, Type I. The sand shall conform to the requirements of ASTM C144.

701-2.6 Joint fillers. Poured filler for joints shall conform to the requirements of ASTM D6690.

701-2.7 Plastic gaskets. Not used.

701-2.8. Controlled low-strength material (clsm). Controlled low-strength material shall conform to the requirements of Item P-153. When CLSM is used, all joints shall have gaskets.

701-2.9 Precast box culverts. Manufactured in accordance with and conforming to ASTM C1433.

701-2.10 Precast concrete pipe. Precast concrete structures shall be furnished by a plant meeting National Precast Concrete Association Plant Certification Program or with American Concrete Pipe Association Qcast Plant Certification program.

CONSTRUCTION METHODS

701-3.1 Excavation. The width of the pipe trench shall be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipe, but it shall not be less than the external diameter of the pipe plus 12 inches (300 mm) on each side. The trench walls shall be approximately vertical.

The Contractor shall comply with all current federal, state and local rules and regulations governing the safety of men and materials during the excavation, installation and backfilling operations. Specifically, the Contractor shall observe that all requirements of the Occupational Safety and Health Administration (OSHA) relating to excavations, trenching and shoring are strictly adhered to. The width of the trench shall be sufficient to permit satisfactorily jointing of the pipe and thorough compaction of the bedding material under the pipe and backfill material around the pipe, but it shall not be greater than the widths shown on the plans trench detail.

Where rock, hardpan, or other unyielding material is encountered, the Contractor shall remove it from below the foundation grade for a depth of at least 8 inch (200 mm) or 1/2 inch (12 mm) for each foot of fill over the top of the pipe (whichever is greater) but for no more than three-quarters of the nominal diameter of the pipe. The excavation below grade should be filled with granular material to form a uniform foundation.

Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unstable soil, the unstable soil shall be removed and replaced with approved granular material for the full trench width. The Construction Manager shall determine the depth of removal necessary. The granular material shall be compacted to provide adequate support for the pipe.

The excavation for pipes placed in embankment fill shall not be made until the embankment has been completed to a height above the top of the pipe as shown on the plans.

701-3.2 Bedding. The bedding surface for the pipe shall provide a foundation of uniform density to support the pipe throughout its entire length.

a. Rigid pipe. The pipe bedding shall be constructed uniformly for the full length of the pipe barrel, as required on the plans. The maximum aggregate size shall be 1 in when the bedding thickness is less than 6 inches, and 1-1/2 in when the bedding thickness is greater than 6 inches. Bedding shall be loosely placed uncompacted material under the middle third of the pipe prior to placement of the pipe.

b. Flexible pipe. For flexible pipe, the bed shall be roughly shaped to fit the pipe, and a bedding blanket of sand or fine granular material shall be provided as follows:

Pipe Corrugation Depth		Minimum Bedding Depth		
inch	mm	inch	mm	
1/2	12	1	25	
1	25	2	50	
2	50	3	75	
2-1/2	60	3-1/2	90	

Flexible Pipe Bedding

c. Other pipe materials. For PVC, polyethylene, polypropylene, or fiberglass pipe, the bedding material shall consist of coarse sands and gravels with a maximum particle size of 3/4 inches (19 mm). For pipes installed under paved areas, no more than 12% of the material shall pass the No. 200 (0.075 mm) sieve. For all other areas, no more than 50% of the material shall pass the No. 200 (0.075 mm) sieve. The bedding shall have a thickness of at least 6 inches (150 mm) below the bottom of the pipe and extend up around the pipe for a depth of not less than 50% of the pipe's vertical outside diameter.

701-3.3 Laying pipe. The pipe laying shall begin at the lowest point of the trench and proceed upgrade. The lower segment of the pipe shall be in contact with the bedding throughout its full length. Bell or groove ends of rigid pipes and outside circumferential laps of flexible pipes shall be placed facing upgrade.

Paved or partially lined pipe shall be placed so that the longitudinal center line of the paved segment coincides with the flow line.

Elliptical and elliptically reinforced concrete pipes shall be placed with the manufacturer's reference lines designating the top of the pipe within five degrees of a vertical plane through the longitudinal axis of the pipe.

701-3.4 Joining pipe. Joints shall be made with (1) cement mortar, (2) cement grout, (3) rubber gaskets, (4) plastic gaskets or (5) coupling bands.

Mortar joints shall be made with an excess of mortar to form a continuous bead around the outside of the pipe and shall be finished smooth on the inside. Molds or runners shall be used for grouted joints to retain the poured grout. Rubber ring gaskets shall be installed to form a flexible watertight seal.

a. Concrete pipe. Concrete pipe may be either bell and spigot or tongue and groove. Pipe sections at joints shall be fully seated and the inner surfaces flush and even. Concrete pipe joints shall be sealed with rubber gaskets meeting ASTM C443.

b. Metal pipe. Metal pipe shall be firmly joined by form-fitting bands conforming to the requirements of ASTM A760 for steel pipe and AASHTO M196 for aluminum pipe.

c. PVC, Polyethylene, or Polypropylene pipe. Joints for PVC, Polyethylene, or Polypropylene pipe shall conform to the requirements of ASTM D3212 when leak resistant joints are required. Joints for PVC and Polyethylene pipe shall conform to the requirements of AASHTO M304 when soil tight joints are required. Fittings for polyethylene pipe shall conform to the requirements of AASHTO M252 or ASTM M294. Fittings for polypropylene pipe shall conform to ASTM F2881, ASTM F2736, or ASTM F2764.

d. Fiberglass pipe. Joints and fittings shall be as detailed on the plans and in accordance with the manufacturers recommendations. Joints shall meet the requirements of ASTM D4161 for flexible elastomeric seals.

701-3.5 Embedment and Overfill. Pipes shall be inspected before any fill material is placed; any pipes found to be out of alignment, unduly settled, or damaged shall be removed and re-laid or replaced at the Contractor's expense.

701-3.5-1 Embedment material requirements

a. Concrete Pipe. Embedment material and compaction requirements shall be in accordance with the applicable Type of Standard Installation (Types 1, 2, 3, or 4) per ASTM C1479. If a concrete cradle or CLSM embedment material is used, it shall conform to the plan details.

b. Plastic and fiberglass Pipe. Embedment material shall meet the requirements of ASTM D3282, A-1, A-2-4, A-2-5, or A-3. Embedment material shall be free of organic material, stones larger than 1.5 inches in the greatest dimension, or frozen lumps. Embedment material shall extend to 12 inches above the top of the pipe.

c. Metal Pipe. Embedment material shall be granular as specified in the contract document and specifications, and shall be free of organic material, rock fragments larger than 1.5 inches in the greatest dimension and frozen lumps. As a minimum, backfill materials shall meet the requirements of ASTM D3282, A-1, A-2, or A-3. Embedment material shall extend to 12 inches above the top of the pipe.

701-3.5-2 Placement of embedment material

The embedment material shall be compacted in layers not exceeding 6 inches (150 mm) on each side of the pipe and shall be brought up one foot (30 cm) above the top of the pipe or to natural ground level, whichever is greater. Thoroughly compact the embedment material under the haunches of the pipe without displacing the pipe. Material shall be brought up evenly on each side of the pipe for the full length of the pipe.

When the top of the pipe is above the top of the trench, the embedment material shall be compacted in layers not exceeding 6 inches (150 mm) and shall be brought up evenly on each side of the pipe to one foot (30 cm) above the top of the pipe. All embedment material shall be compacted to a density required under Item P-152.

Concrete cradles and flowable fills, such as controlled low strength material (CLSM) or controlled density fill (CDF), may be used for embedment provided adequate flotation resistance can be achieved by restraints, weighing, or placement technique.

It shall be the Contractor's responsibility to protect installed pipes and culverts from damage due to construction equipment operations. The Contractor shall be responsible for installation of any extra strutting or backfill required to protect pipes from the construction equipment.

701-3.6 Overfill

Pipes shall be inspected before any overfill is in place. Any pipes found to be out of alignment, unduly settled, or damaged shall be removed and relaid or replaced at the Contractor's expense. Evaluation of any damage to RCP shall be evaluated based on AASHTO R73.

Overfill material shall be place and compacted in layers as required to achieve compaction to at least 95 percent standard proctor per ASTM D1557. The soil shall contain no debris, organic matter, frozen material, or stones with a diameter greater than one half the thickness of the compacted layers being placed.

701-3.7 Inspection requirements

An initial post installation inspection shall be performed by the Construction Manager no sooner than 30 days after completion of installation and final backfill. Clean or flush all lines prior to inspection.

Use a camera with lighting suitable to allow a clear picture of the entire periphery of the pipe interior. Center the camera in the pipe both vertically and horizontally and be able to pan and tilt to a 90 degree angle with the axis of the pipe rotating 360 degrees. Use equipment to move the camera through the pipe that will not obstruct the camera's view or interfere with proper documentation of the pipe's condition. The video image shall be clear, focused, and relatively free from roll, static, or other image distortion qualities that would prevent the reviewer from evaluating the condition of the pipe.

For pipe sizes larger than 48 inches, a walk-through visual inspection shall be performed.

Incorporate specific inspection requirements for the various types of pipes beneath the general inspection requirements.

Reinforced concrete pipe shall be inspected, evaluated, and reported on in accordance with ASTM C1840, "Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain, and Storm Sewer Pipe." Any issues reported shall include still photo and video documentation. The zoom ratio shall be provided for all still or video images that document any issues of concern by the inspection firm.

Flexible pipes shall be inspected for rips, tears, joint separations, soil migration, cracks, localized buckling, settlement, alignment, and deflection. Determine whether the allowable deflection has been exceeded by use of a laser profiler for internal pipe diameters of 48 inches or less, or direct measurement for internal pipe diameters greater than 48 inches. Laser profile equipment shall utilize low barrel distortion video equipment. Deflection of installed pipe shall not exceed the limits provided in the table below, as a percentage of the average inside diameter of the pipe.

Type of Pipe	Maximum Allowable Deflection (%)
Corrugated Metal Pipe	5
Concrete Lined CMP	3
Thermoplastic Pipe	5
Fiberglass	5

Maximum Allowable Pipe Deflection

If deflection readings in excess of the allowable deflection are obtained, remove the pipe with excessive deflection and replace with new pipe. Repair or replace any pipe with cracks exhibiting displacement across the crack, bulges, creases, tears, spalls, or delaminations. The report for flexible pipe shall include as a minimum, the deflection results and final post installation inspection report. The inspection report shall include: a copy of all video taken, pipe location identification, equipment used for inspection, inspector name, deviation from design line and grade, and inspector's notes.

METHOD OF MEASUREMENT

701-4.1 The length of pipe shall be measured in linear feet (m) of pipe in place, completed, and accepted. It shall be measured along the centerline of the pipe from end or inside face of structure to the end or inside face of structure, whichever is applicable. The class, types and size of pipe shall be measured separately. All fittings shall be included in the footage as typical pipe sections in the pipe being measured.

BASIS OF PAYMENT

701-5.0 These prices shall fully compensate the Contractor for furnishing all materials and for all preparation, excavation, backfill, and installation of these materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

701-5.1 Payment will be made at the contract unit price per linear foot (meter) for identify each class and size of pipe.

Payment will be made under:

Item 701-1	Remove Storm Drain Pipe – per linear foot (meter)
Item 701-2	Install 30" RCP Class V Storm Drain Pipe – per linear foot (meter)
Item 701-3	Install 29x45" RCP Class III Storm Drain Pipe – per linear foot (meter)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

American Association of State Highway and Transportation Officials (AASHTO)

AASHTO M167 Standard Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches

AASHTO M190	Standard Specification for Bituminous-Coated Corrugated Metal Culvert Pipe and Pipe Arches
AASHTO M196	Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains
AASHTO M219	Standard Specification for Corrugated Aluminum Alloy Structural Plate for Field-Bolted Pipe, Pipe-Arches, and Arches
AASHTO M243	Standard Specification for Field Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches
AASHTO M252	Standard Specification for Corrugated Polyethylene Drainage Pipe
AASHTO M294	Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500- mm (12- to 60-in.) Diameter
AASHTO M304	Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Wall Drain Pipe and Fittings Based on Controlled Inside Diameter
AASHTO MP20	Standard Specification for Steel Reinforced Polyethylene (PE) Ribbed Pipe, 300- to 900-mm (12- to 36-in.) Diameter
ASTM International (ASTM)	
ASTM A760	Standard Specification for Corrugated Steel Pipe, Metallic Coated for Sewers and Drains
ASTM A761	Standard Specification for Corrugated Steel Structural Plate, Zinc Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches
ASTM A762	Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains
ASTM A849	Standard Specification for Post-Applied Coatings, Pavings, and Linings for Corrugated Steel Sewer and Drainage Pipe
ASTM B745	Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains
ASTM C14	Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C76	Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C94	Standard Specification for Ready Mixed Concrete
ASTM C144	Standard Specification for Aggregate for Masonry Mortar
ASTM C150	Standard Specification for Portland Cement

ASTM C443	Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C506	Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
ASTM C507	Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer Pipe
ASTM C655	Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain and Sewer Pipe
ASTM C990	Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C1433	Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM D1056	Standard Specification for Flexible Cellular Materials Sponge or Expanded Rubber
ASTM D3034	Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3262	Standard Specification for "Fiberglass" (Glass-Fiber Reinforced Thermosetting Resin) Sewer Pipe
ASTM D3282	Standard Practice for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
ASTM D4161	Standard Specification for "Fiberglass" (Glass-Fiber Reinforced Thermosetting Resin) Pipe Joints Using Flexible Elastomeric Seals
ASTM D6690	Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM F477	Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F667	Standard Specification for 3 through 24 in. Corrugated Polyethylene Pipe and Fittings
ASTM F714	Standard Specification for Polyethylene (PE) Plastic Pipe (DR PR) Based on Outside Diameter
ASTM F794	Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe & Fittings Based on Controlled Inside Diameter

ASTM F894	Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F949	Standard Specification for Poly (Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings
ASTM F2435	Standard Specification for Steel Reinforced Polyethylene (PE) Corrugated Pipe
ASTM F2562	Specification for Steel Reinforced Thermoplastic Ribbed Pipe and Fittings for Non-Pressure Drainage and Sewerage
ASTM F2736	Standard Specification for 6 to 30 in. (152 to 762 mm) Polypropylene (PP) Corrugated Single Wall Pipe and Double Wall Pipe
ASTM F2764	Standard Specification for 30 to 60 in. (750 to 1500 mm) Polypropylene (PP) Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications
ASTM F2881	Standard Specification for 12 to 60 in. (300 to 1500 mm) Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications

National Fire Protection Association (NFPA)

NFPA 415	Standard on Airport	Terminal	Buildings,	Fueling	Ramp	Drainage,	and
	Loading Walkways						

END ITEM D-701

ITEM D-705 PIPE UNDERDRAINS FOR AIRPORTS

DESCRIPTION

705-1.1 This item shall consist of the construction of pipe drains in accordance with these specifications and in reasonably close conformity with the lines and grades shown on the plans.

MATERIALS

705-2.1 General. Materials shall meet the requirements shown on the plans and specified below.

705-2.2 Pipe. The pipe shall be of the type called for on the plans or in the proposal and shall be in accordance with the following appropriate requirements.

ASTM F758 Standard Specification for Smooth-Wall Poly (Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage

705-2.3 Joint mortar. Pipe joint mortar shall consist of one part by volume of Portland cement and two parts sand. The Portland cement shall conform to the requirements of ASTM C150, Type I. The sand shall conform to the requirements of ASTM C144.

705-2.4 Elastomeric seals. Elastomeric seals shall conform to the requirements of ASTM F477.

705-2.5 Porous backfill. Porous backfill shall be free of clay, humus, or other objectionable matter, and shall conform to the gradation in Table 1 when tested in accordance with ASTM C136.

Since Designation (square enonings)	Percentage by Weight Passing Sieves		
Sieve Designation (square openings)	Porous Material No. *		
1-1/2 inch (37.5 mm)	100		
1 inch (25.0 mm)	90 - 100		
3/8 inch (9.5 mm)	25 - 60		
No. 4 (4.75 mm)	5 - 40		
No. 8 (2.36 mm)	0 - 20		

Table 1. Gradation of Porous Backfill

When two courses of porous backfill are specified in the plans, the finer of the materials shall conform to particle size tabulated herein for porous material No. 1. The coarser granular material shall meet the gradation given in the tabulation for porous material No. 2.

705-2.6 Granular material. Granular material used for backfilling shall conform to the requirements of ASTM D2321 for Class IA, IB, or II materials.

705-2.7 Filter fabric. The filter fabric shall conform to the requirements of AASHTO M288 Class 2 or equivalent.

Fabric Property	Test Method	Test Requirement	
Grab Tensile Strength, lbs	ASTM D4632	125 min	
Grab Tensile Elongation %	ASTM D4632	50 min	
Burst Strength, psi	ASTM D3785	125 min	
Trapezoid Tear Strength, lbs	ASTM D4533	55 min	
Puncture Strength, lbs	ASTM D4833	40 min	
Abrasion, lbs	ASTM D4886	15 max loss	
Equivalent Opening Size	ASTM D4751	70-100	
Permittivity sec ⁻¹	ASTM D4491	0.80	
Accelerated Weathering (UV Stability)	ASTM D4355	70	
(Strength Retained - %)	*(500 hrs exposure)	70	

Table 2. Fabric Properties

705-2.8 Controlled low-strength material (CLSM). Controlled low-strength material shall conform to the requirements of Item P-153. All joints shall have elastomeric seals.

CONSTRUCTION METHODS

705-3.1 Equipment. All equipment required for the construction of pipe underdrains shall be on the project, in good working condition, and approved by the Construction Manager before construction is permitted to start.

705-3.2 Excavation. The width of the pipe trench shall be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipe, but shall not be less than the external diameter of the pipe plus 6 inches (150 mm) on each side of the pipe. The trench walls shall be approximately vertical.

Where rock, hardpan, or other unyielding material is encountered, it shall be removed below the foundation grade for a depth of at least 4 inches (100 mm). The excavation below grade shall be backfilled with selected fine compressible material, such as silty clay or loam, and lightly compacted in layers not over 6 inches (150 mm) in uncompacted depth to form a uniform but yielding foundation.

Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unstable soil, the unstable soil shall be removed and replaced with approved granular material for the full trench width. The Construction Manager shall determine the depth of removal necessary. The granular material shall be compacted to provide adequate support for the pipe.

Excavated material not required or acceptable for backfill shall be disposed of by the Contractor as directed by the Construction Manager. The excavation shall not be carried below the required depth; if this occurs, the trench shall be backfilled at the Contractor's expense with material approved by the Construction Manager and compacted to the density of the surrounding material.

The pipe bedding shall be constructed uniformly over the full length of the pipe barrel, as required on the plans. The maximum aggregate size shall be 1 inch when the bedding thickness is less than 6 inches, and 1-1/2 inch when the bedding thickness is greater than 6 inches. Bedding shall be loosely placed, uncompacted material under the middle third of the pipe prior to placement of the pipe.

The Contractor shall do trench bracing, sheathing, or shoring necessary to perform and protect the excavation as required for safety and conformance to federal, state and local laws. Unless otherwise

provided, the bracing, sheathing, or shoring shall be removed by the Contractor after the backfill has reached at least 12 inches (300 mm) over the top of the pipe. The sheathing or shoring shall be pulled as the granular backfill is placed and compacted to avoid any unfilled spaces between the trench wall and the backfill material. The cost of bracing, sheathing, or shoring, and the removal of same, shall be included in the unit price bid per foot (meter) for the pipe.

705-3.3 Laying and installing pipe.

a. Concrete pipe. The laying of the pipe in the finished trench shall be started at the lowest point and proceed upgrade. When bell and spigot pipe is used, the bells shall be laid upgrade. If tongue and groove pipe is used, the groove end shall be laid upgrade. Holes in perforated pipe shall be placed down, unless otherwise shown on the plans. The pipe shall be firmly and accurately set to line and grade so that the invert will be smooth and uniform. Pipe shall not be laid on frozen ground.

Pipe which is not true in alignment, or which shows any settlement after laying, shall be taken up and re-laid by the Contractor at no additional expense. Making adjustments in grade by exerting force on the barrel of the pipe with excavating equipment, by lifting and dropping the pipe, or by lifting the pipe and packing bedding material under it shall be prohibited. If the installed pipe section is not to grade, the pipe section shall be completely removed, the grade corrected, and the pipe rejoined."

b. Metal pipe. The metal pipe shall be laid with the separate sections joined firmly together with bands, with outside laps of circumferential joints pointing upgrade, and with longitudinal laps on the sides. Any metal in the pipe or bands that is not protected thoroughly by galvanizing shall be coated with a suitable asphaltum paint.

During installation, the asphalt-protected pipe shall be handled without damaging the asphalt coating. Any breaks in the bitumen or treatment of the pipe shall be refilled with the type and kind of bitumen used in coating the pipe originally.

c. PVC, fiberglass, or polyethylene pipe. PVC or polyethylene pipe shall be installed in accordance with the requirements of ASTM D2321. Perforations shall meet the requirements of AASHTO M252 or AASHTO M294 Class 2, unless otherwise indicated on the plans. The pipe shall be laid accurately to line and grade. Fiberglass per ASTM D3839 Standard Guide for Underground Installation of "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe.

d. All types of pipe. The upgrade end of pipelines, not terminating in a structure, shall be plugged or capped as approved by the Construction Manager.

Unless otherwise shown on the plans, a 4-inch (100 mm) bed of granular backfill material shall be spread in the bottom of the trench throughout the entire length under all perforated pipe underdrains.

Pipe outlets for the underdrains shall be constructed when required or shown on the plans. The pipe shall be laid with tight-fitting joints. Porous backfill is not required around or over pipe outlets for underdrains. All connections to other drainage pipes or structures shall be made as required and in a satisfactory manner. If connections are not made to other pipes or structures, the outlets shall be protected and constructed as shown on the plans.

e. Filter fabric. The filter fabric shall be installed in accordance with the manufacturer's recommendations, or in accordance with the AASHTO M288 Appendix, unless otherwise shown on the plans.

705-3.4 Mortar. The mortar shall be of the desired consistency for caulking and filling the joints of the pipe and for making connections to other pipes or to structures. Mortar that is not used within 45 minutes after water has been added shall be discarded. Retempering of mortar shall not be permitted.

705-3.5 Joints in concrete pipe. When open or partly open joints are required or specified, they shall be constructed as indicated on the plans. The pipe shall be laid with the ends fitted together as designed. If bell and spigot pipe is used, mortar shall be placed along the inside bottom quarter of the bell to center the following section of pipe.

The open or partly open joints shall be surrounded with granular material meeting requirements of porous backfill No. 2 in Table 1 or as indicated on the plans. This backfill shall be placed so its thickness will be not less than 3 inches (75 mm) nor more than 6 inches (150 mm), unless otherwise shown on the plans.

When the original material excavated from the trench is impervious, commercial concrete sand or granular material meeting requirements of porous backfill No. 1 shall surround porous backfill No. 2 (Table 1), as shown on the plans or as directed by the Construction Manager.

When the original material excavated from the trench is pervious and suitable, it may be used as backfill in lieu of porous backfill No. 1, when indicated on the plans or as directed by the Construction Manager.

705-3.6 Embedment and backfill

a. Earth. All trenches and excavations shall be backfilled soon after the pipes are installed, unless additional protection of the pipe is directed. The embedment material shall be select material from excavation or borrow and shall be approved by the Construction Manager. The select material shall be placed on each side of the pipe out to a distance of the nominal pipe diameter and one foot (30 cm) over the top of the pipe and shall be readily compacted. It shall not contain stones 3 inches (75 mm) or larger in size, frozen lumps, chunks of highly plastic clay, or any other material that is objectionable to the Construction Manager. The material shall be moistened or dried, as required to aid compaction. Placement of the embedment material shall not cause displacement of the pipe. Thorough compaction under the haunches and along the sides to the top of the pipe shall be obtained.

The embedment material shall be placed in loose layers not exceeding 6 inches (150 mm) in depth under and around the pipe. Backfill material over the pipe shall be placed in lifts not exceeding 8 inches (200 mm). Successive layers shall be added and thoroughly compacted by hand and pneumatic tampers, approved by the Construction Manager, until the trench is completely filled and brought to the planned elevation. Embedment and backfilling shall be done to avoid damaging top or side of the pipe.

In embankments and other unpaved areas, the backfill shall be compacted per Item P-152 to the density required for embankments in unpaved areas. Under paved areas, the subgrade and any backfill shall be compacted per Item P-152 to the density required for embankments for paved areas.

b. Granular backfill. When granular backfill is required, placement in the trench and about the pipe shall be as shown on the plans. The granular backfill shall not contain an excessive amount of foreign matter, nor shall soil from the sides of the trench or from the soil excavated from the trench be allowed to filter into the granular backfill. When required by the Construction Manager, a template shall be used to properly place and separate the two sizes of backfill. The backfill shall be placed in loose layers not exceeding 6 inches (150 mm) in depth. The granular backfill shall be compacted by hand and pneumatic tampers to the requirements as given for embankment. Backfilling shall be done to avoid damaging top or side pressure on the pipe. The granular backfill shall extend to the elevation of the trench or as shown on the plans.

When perforated pipe is specified, granular backfill material shall be placed along the full length of the pipe. The position of the granular material shall be as shown on the plans. If the original material excavated from the trench is pervious and suitable, it shall be used in lieu of porous backfill No. 1.

If porous backfill is placed in paved or adjacent to paved areas before grading or subgrade operations is completed, the backfill material shall be placed immediately after laying the pipe. The depth of the granular backfill shall be not less than 12 inches (300 mm), measured from the top of the underdrain. During subsequent construction operations, a minimum depth of 12 inches (300 mm) of backfill shall be maintained over the underdrains. When the underdrains are to be completed, any unsuitable material shall be removed exposing the porous backfill. Porous backfill containing objectionable material shall be removed and replaced with suitable material. The cost of removing and replacing any unsuitable material shall be at the Contractor's expense.

If a granular subbase blanket course is used which extends several feet beyond the edge of paving to the outside edge of the underdrain trench, the granular backfill material over the underdrains shall be placed in the trench up to an elevation of 2 inches (50 mm) above the bottom surface of the granular subbase blanket course. Immediately prior to the placing of the granular subbase blanket course, the Contractor shall blade this excess trench backfill from the top of the trench onto the adjacent subgrade where it can be incorporated into the granular subbase blanket course. Any unsuitable material that remains over the underdrain trench shall be removed and replaced. The subbase material shall be placed to provide clean contact between the subbase material and the underdrain granular backfill material for the full width of the underdrain trench.

c. Controlled low-strength material (CLSM). Controlled low-strength material shall conform to the requirements of Item P-153.

705-3.7 Flexible pipe ring deflection. The flexible pipe shall be inspected by the Contractor during and after installation to ensure that the internal diameter of the pipe barrel has not been reduced by more than 5 percent. For guidance on properly sizing mandrels, refer to ASTM D3034 and ASTM F679 appendices.

705-3.8 Connections. When the plans call for connections to existing or proposed pipe or structures, these connections shall be watertight and made to obtain a smooth uniform flow line throughout the drainage system.

705-3.9 Cleaning and restoration of site. After the backfill is completed, the Contractor shall dispose of all surplus material, soil, and rubbish from the site. Surplus soil may be deposited in embankments, shoulders, or as directed by the Construction Manager. Except for paved areas of the airport, the Contractor shall restore all disturbed areas to their original condition.

705-3.10 Removal of underdrain pipe. The existing underdrain pipe shall be removed including all porous backfill, fabric, and fittings. Excavation areas shall be backfilled and compacted with native material or controlled import material as required to meet adjacent improvements.

METHOD OF MEASUREMENT

705-4.1 The length of underdrain trench restoration shall be the number of linear feet (meters) of underdrain trench restored in place, completed, and approved; measured along the centerline of the pipe/trench from end or inside face of structure to the end or inside face of structure, whichever is applicable. All fittings, porous backfill, filter fabric and appurtenances shall be included in the footage as typical restoration sections being measured.

BASIS OF PAYMENT

705-5.1 Payment will be made at the contract unit price per linear foot (meter) for pipe underdrain restoration of the existing underdrain trench as shown on the drawings. The price shall be full compensation for furnishing all materials and for all preparation, excavation, backfill, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

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Item D-705-1 Underdrain Restoration – per linear foot (meter)
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REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM A760	Standard Specification for Corrugated Steel Pipe, Metallic Coated for Sewers and Drains
ASTM A762	Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C144	Standard Specification for Aggregate for Masonry Mortar
ASTM C150	Standard Specification for Portland Cement
ASTM C444	Standard Specification for Perforated Concrete Pipe
ASTM C654	Standard Specification for Porous Concrete Pipe
ASTM D2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

ASTM D3262	Standard Specification for "Fiberglass" (Glass-Fiber Reinforce Thermosetting Resin) Sewer Pipe
ASTM D4161	Standard Specification for "Fiberglass" (Glass-Fiber Reinforced Thermosetting Resin) Pipe Joints Using Flexible Elastomeric Seals
ASTM F477	Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F758	Standard Specification for Smooth Wall Poly (Vinyl Chloride) (PVC Plastic Underdrain Systems for Highway, Airport, and Similar Drainage
ASTM F794	Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe & Fittings Based on Controlled Inside Diameter
ASTM F949	Standard Specification for Poly (Vinyl Chloride) (PVC) Corrugated Sewe Pipe with a Smooth Interior and Fittings
ASTM F2562	Specification for Steel Reinforced Thermoplastic Ribbed Pipe and Fitting for Non-Pressure Drainage and Sewerage

American Association of State Highway and Transportation Officials (AASHTO)

AASHTO M190	Standard Specification for Bituminous - Coated Corrugated Metal Culvert Pipe and Pipe Arches
AASHTO M196	Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains
AASHTO M252	Standard Specification for Corrugated Polyethylene Drainage Pipe
AASHTO M288	Standard Specification for Geotextile Specification for Highway Applications
AASHTO M294	Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500- mm (12- to 60-in.) Diameter
AASHTO M304	Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Wall Drain Pipe and Fittings Based on Controlled Inside Diameter
AASHTO MP20	Standard Specification for Steel-Reinforced Polyethylene (PE) Ribbed Pipe, 300- to 900-mm (12- to 36-in.) diameter
AASHTO	Standard Specifications for Highway Bridges

END OF ITEM D-705

ITEM D-751 MANHOLES, CATCH BASINS, INLETS AND INSPECTION HOLES

DESCRIPTION

<u>751-1.1</u> This item shall consist of construction of manholes, catch basins, inlets, and inspection holes, in accordance with these specifications, at the specified locations and conforming to the lines, grades, and dimensions shown on the plans or as required by the Construction Manager.

MATERIALS

751-2.1 BRICK. The brick shall conform to the requirements of ASTM C32, Grade MS.

<u>751-2.2 MORTAR.</u> Mortar shall consist of one part Portland cement and two parts sand. The cement shall conform to the requirements of ASTM C150, Type I. The sand shall conform to the requirements of ASTM C144.

<u>751-2.3 CONCRETE.</u> Plain and reinforced concrete used in structures, connections of pipes with structures, and the support of structures or frames shall conform to the requirements of Item P-610.

751-2.4 PRECAST CONCRETE PIPE MANHOLE RINGS. Precast concrete pipe manhole rings shall conform to the requirements of ASTM C478. Unless otherwise specified, the risers and offset cone sections shall have an inside diameter of not less than 36 inches (90 cm) nor more than 48 inches (120 cm). There shall be a gasket between individual sections and sections cemented together with mortar on the inside of the manhole. Gaskets shall conform to the requirements of ASTM C443.

<u>751-2.5 CORRUGATED METAL</u>. Corrugated metal shall conform to the requirements of American Association of State Highway and Transportation Officials (AASHTO) M36.

751-2.6 FRAMES, COVERS, AND GRATES. The castings shall conform to one of the following requirements:

- **a.** ASTM A48, Class 35B: Gray iron castings
- **b.** ASTM A47: Malleable iron castings
- **c.** ASTM A27: Steel castings
- d. ASTM A283, Grade D: Structural steel for grates and frames
- e. ASTM A536, Grade 65-45-12: Ductile iron castings
- **f.** ASTM A897: Austempered ductile iron castings

All castings or structural steel units shall conform to the dimensions shown on the plans and shall be designed to support the loadings, aircraft gear configuration and/or direct loading, specified.

Each frame and cover or grate unit shall be provided with fastening members to prevent it from being dislodged by traffic but which will allow easy removal for access to the structure.

All castings shall be thoroughly cleaned. After fabrication, structural steel units shall be galvanized to meet the requirements of ASTM A123.

<u>751-2.7 STEPS.</u> The steps or ladder bars shall be gray or malleable cast iron or galvanized steel. The steps shall be the size, length, and shape shown on the plans and those steps that are not galvanized shall be given a coat of asphalt paint, when directed.

<u>751-2.8 PRECAST INLET STRUCTURES.</u> Manufactured in accordance with and conforming to ASTM C913.

CONSTRUCTION METHODS

751-3.1 UNCLASSIFIED EXCAVATION.

a. The Contractor shall excavate for structures and footings to the lines and grades or elevations, shown on the plans, or as staked by the Construction Manager. The excavation shall be of sufficient size to permit the placing of the full width and length of the structure or structure footings shown. The elevations of the bottoms of footings, as shown on the plans, shall be considered as approximately only; and the Construction Manager may direct, in writing, changes in dimensions or elevations of footings necessary for a satisfactory foundation.

b. Boulders, logs, or any other objectionable material encountered in excavation shall be removed. All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface either level, stepped, or serrated, as directed by the Construction Manager. All seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed. Where concrete will rest on a surface other than rock, the bottom of the excavation shall not be disturbed and excavation to final grade shall not be made until immediately before the concrete or reinforcing is placed.

c. The Contractor shall do all bracing, sheathing, or shoring necessary to implement and protect the excavation and the structure as required for safety or conformance to governing laws. The cost of bracing, sheathing, or shoring shall be included in the unit price bid for the structure.

d. All bracing, sheathing, or shoring involved in the construction of this item shall be removed by the Contractor after the completion of the structure. Removal shall not disturb or damage finished masonry. The cost of removal shall be included in the unit price bid for the structure.

e. After excavation is completed for each structure, the Contractor shall notify the Construction Manager. No concrete or reinforcing steel shall be placed until the Construction Manager has approved the depth of the excavation and the character of the foundation material.

751-3.2 BRICK STRUCTURES.
a. Foundations. A prepared foundation shall be placed for all brick structures after the foundation excavation is completed and accepted. Unless otherwise specified, the base shall consist of reinforced concrete mixed, prepared, and placed in accordance with the requirements of Item P-610.

b. Laying brick. All brick shall be clean and thoroughly wet before laying so that they will not absorb any appreciable amount of additional water at the time they are laid. All brick shall be laid in freshly made mortar. Mortar not used within 45 minutes after water has been added shall be discarded. Retempering of mortar shall not be permitted. An ample layer of mortar shall be spread on the beds and a shallow furrow shall be made in it that can be readily closed by the laying of the brick. All bed and head joints shall be filled solid with mortar. End joints of stretchers and side or cross joints of headers shall be fully buttered with mortar and a shoved joint made to squeeze out mortar at the top of the joint. Any bricks that may be loosened after the mortar has taken its set, shall be removed, cleaned, and re-laid with fresh mortar. No broken or chipped brick shall be used in the face, and no spalls or bats shall be used except where necessary to shape around irregular openings or edges; in which case, full bricks shall be placed at ends or corners where possible, and the bats shall be used in the interior of the course. In making closures, no piece of brick shorter than the width of a whole brick shall be used; and wherever practicable, whole brick shall be used and laid as headers.

c. Joints. All joints shall be filled with mortar at every course Exterior faces shall be laid up in advance of backing. Exterior faces shall be plastered or parged with a coat of mortar not less than 3/8 inch (9 mm) thick before the backing is laid up. Prior to parging, all joints on the back of face courses shall be cut flush. Unless otherwise noted, joints shall be not less than 1/4 inch (6 mm) nor more than 1/2 inch (12 mm) wide and the selected joint width shall be maintained uniform throughout the work.

d. Pointing. Face joints shall be neatly struck, using the weather-struck joint. All joints shall be finished properly as the laying of the brick progresses. When nails or line pins are used, the holes shall be immediately plugged with mortar and pointed when the nail or pin is removed.

e. Cleaning. Upon completion of the work all exterior surfaces shall be thoroughly cleaned by scrubbing and washing with water. If necessary to produce satisfactory results, cleaning shall be done with a 5% solution of muriatic acid which shall then be rinsed off with liberal quantities of water.

f. Curing and cold weather protection. The brick masonry shall be protected and kept moist for at least 48 hours after laying the brick. Brick masonry work or pointing shall not be done when there is frost on the brick or when the air temperature is below 50°F (10° C) unless the Contractor has, on the project ready to use, suitable covering and artificial heating devices necessary to keep the atmosphere surrounding the masonry at a temperature of not less than 60°F (16° C) for the duration of the curing period.

<u>751-3.3 CONCRETE STRUCTURES</u>. Concrete structures which are to be cast-in-place within the project boundaries shall be built on prepared foundations, conforming to the dimensions and shape indicated on the plans. The construction shall conform to the requirements specified in Item P-610. Any reinforcement required shall be placed as indicated on the plans and shall be approved by the CONSTRUCTION MANAGER before the concrete is placed.

All invert channels shall be constructed and shaped accurately to be smooth, uniform, and cause minimum resistance to flowing water. The interior bottom shall be sloped to the outlet.

<u>751-3.4 PRECAST CONCRETE STRUCTURES.</u> Precast concrete structures shall be furnished by a plant meeting National Precast Concrete Association Plant Certification Program or another Engineer approved third party certification program.

Precast concrete structures shall conform to ASTM C478. Precast concrete structures shall be constructed on prepared or previously placed slab foundations conforming to the dimensions and locations shown on the plans. All precast concrete sections necessary to build a completed structure shall be furnished. The different sections shall fit together readily. Joints between precast concrete risers and tops shall be fullbedded in cement mortar and shall: (1) be smoothed to a uniform surface on both interior and exterior of the structure or (2) utilize a rubber gasket per ASTM C443. The top of the upper precast concrete section shall be suitably formed and dimensioned to receive the metal frame and cover or grate, or other cap, as required. Provision shall be made for any connections for lateral pipe, including drops and leads that may be installed in the structure. The flow lines shall be smooth, uniform, and cause minimum resistance to flow. The metal or metal encapsulated steps that are embedded or built into the side walls shall be aligned and placed in accordance to ASTM C478. When a metal ladder replaces the steps, it shall be securely fastened into position.

751-3.5 CORRUGATED METAL STRUCTURES. Not used.

751-3.6 INLET AND OUTLET PIPES. Inlet and outlet pipes shall extend through the walls of the structures a sufficient distance beyond the outside surface to allow for connections. They shall be cut off flush with the wall on the inside surface of the structure, unless otherwise directed. For concrete or brick structures, mortar shall be placed around these pipes to form a tight, neat connection.

751-3.7 PLACEMENT AND TREATMENT OF CASTINGS, FRAMES, AND FITTINGS. All castings, frames, and fittings shall be placed in the positions indicated on the plans or as directed by the Engineer, and shall be set true to line and elevation. If frames or fittings are to be set in concrete or cement mortar, all anchors or bolts shall be in place before the concrete or mortar is placed. The unit shall not be disturbed until the mortar or concrete has set.

When frames or fittings are placed on previously constructed masonry, the bearing surface of the masonry shall be brought true to line and grade and shall present an even bearing surface so the entire face or back of the unit will come in contact with the masonry. The unit shall be set in mortar beds and anchored to the masonry as indicated on the plans or as directed by the Engineer. All units shall set firm and secure.

After the frames or fittings have been set in final position, the concrete or mortar shall be allowed to harden for seven (7) days before the grates or covers are placed and fastened down.

751-3.8 INSTALLATION OF STEPS. The steps shall be installed as indicated on the plans or as directed by the Engineer. When the steps are to be set in concrete, they shall be placed and secured in position before the concrete is placed. When the steps are installed in brick masonry, they shall be placed as the masonry is being built. The steps shall not be disturbed or used until the concrete or mortar has hardened for at least seven (7) days. After seven (7) days, the steps shall be cleaned and painted, unless they have been galvanized.

When steps are required with precast concrete structures they shall meet the requirements of ASTM C478. The steps shall be cast into the side of the sections at the time the sections are manufactured or set in place after the structure is erected by drilling holes in the concrete and cementing the steps in place.

When steps are required with corrugated metal structures, they shall be welded into aligned position at a vertical spacing of 12 inches (300 mm).

Instead of steps, prefabricated ladders may be installed. For brick or concrete structures, the ladder shall be held in place by grouting the supports in drilled holes. For metal structures, the ladder shall be secured by

welding the top support to the structure and grouting the bottom support into drilled holes in the foundation or as directed by the Engineer.

751-3.9 BACKFILLING.

a. After a structure has been completed, the area around it shall be backfilled with approved material, in horizontal layers not to exceed 8 inches (200 mm) in loose depth, and compacted to the density required in Item P-152. Each layer shall be deposited evenly around the structure to approximately the same elevation. The top of the fill shall meet the elevation shown on the plans or as directed by the Engineer.

b. Backfill shall not be placed against any structure until approved by the Engineer. For concrete structures, approval shall not be given until the concrete has been in place seven (7) days, or until tests establish that the concrete has attained sufficient strength to withstand any pressure created by the backfill and placing methods.

c. Backfill shall not be measured for direct payment. Performance of this work shall be considered an obligation of the Contractor covered under the contract unit price for the structure involved.

751-3.10 Cleaning and restoration of site. After the backfill is completed, the Contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankments, shoulders, or as approved by the Construction Manager. The Contractor shall restore all disturbed areas to their original condition. The Contractor shall remove all tools and equipment, leaving the entire site free, clear, and in good condition.

751-3.11 BURIED STRUCTURE MONUMENT. Existing buried structure monuments shall be surveyed, recorded, and submitted to the Construction Manager prior to commencing demolition within a given construction areas. Upon approval from the Construction Manager the Contractor may proceed with demolition for the surveyed area and project phasing requirements. All monuments shall be restored as included in the plans.

METHOD OF MEASUREMENT

751-4.1 Manholes, catch basins, inlets, and inspection holes shall be measured by the unit.

BASIS OF PAYMENT

751-5.1 The accepted quantities of manholes, catch basins, inlets, and inspection holes will be paid for at the contract unit price per each in place when completed. This price shall be full compensation for furnishing all materials and for all preparation, excavation, backfilling and placing of the materials; furnishing and installation of such specials and connections to pipes and other structures as may be required to complete the item as shown on the plans; and for all labor equipment, tools and incidentals necessary to complete the structure.

751.5.2 Construction of buried junction monuments will be paid for at the contract unit price per each in place when completed. This price shall be full compensation to survey, record, and demolishing existing monuments in addition to the replacement or construction of new monuments. This item shall include the furnishing of all materials and for all labor, equipment, tools, and incidentals necessary to complete the structure.

Payment will be made under:

Item D-751-1	Remove Drop Inlet – per each
Item D-751-2	Construct Aircraft Rated Drop Inlet (36"x70") – per each
Item D-751-3	Survey, Record, Demo, and Construct Buried Structure Monument - per each
Item D-751-4	Adjust Cleanout to Grade – per each

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM A27	Standard Specification for Steel Castings, Carbon, for General Application
ASTM A47	Standard Specification for Ferritic Malleable Iron Castings
ASTM A48	Standard Specification for Gray Iron Castings
ASTM A123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A283	Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A536	Standard Specification for Ductile Iron Castings
ASTM A897	Standard Specification for Austempered Ductile Iron Castings
ASTM C32	Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C144	Standard Specification for Aggregate for Masonry Mortar
ASTM C150	Standard Specification for Portland Cement
ASTM C443	Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
ASTM C478	Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C913	Standard Specification for Precast Concrete Water and Wastewater Structures.

American Association of State Highway and Transportation Officials (AASHTO)

AASHTO M36 Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains

END OF ITEM D-751

Item D-752 Concrete Culverts, Headwalls, and Miscellaneous Drainage Structures

DESCRIPTION

752-1.1 This item shall consist of reinforced concrete culverts, headwalls, and miscellaneous drainage structures constructed in accordance with these specifications, at the specified locations and conforming to the lines, grades, and dimensions shown on the plans or required by the RPR.

MATERIALS

752-2.1 Concrete. Reinforced concrete shall meet the requirements of Item P-610.

752-2.2 Rip Rap. Stone for riprap shall be angular fractured stone or rounded cobblestone, except that cobblestone shall not be used on slopes steeper that 1 vertical to 2 horizontal. Stone shall be of such shape to form a stable protection structure for the required section. Flat or elongated shapes will not be accepted unless the thickness of the individual pieces is at least 1/3 the length.

Stones shall be sound, durable, hard, resistant to abrasion and free from laminations, weak cleavage planes, and the undesirable effects of weathering. It shall be of such character that it will not disintegrate from the action of air, water, or the conditions experienced during handling and placing. All material shall be clean and free from deleterious impurities, including alkali, earth, clay, refuse, and adherent coatings.

Riprap material shall meet the requirements outlined in Table 1 and Table 2.

Table 1 - Gradations Requirements for Riprap and Riprap bedding				
0/ hy size	Size (inches)			
70 Dy Size	Class 150	Class 150	Class 300	Class 300
passing	Riprap Bedding	Riprap	Riprap Bedding	Riprap
100	4	10	10	20
70-85		9	9	18
30-50	1	6	6	12
5-15	3⁄4	2	2	5
0-5	#4	1	1	2
$\mathbf{D}_{50}{}^1$		6	6	12

Table 1 - Gradations Requirements for Riprap and Riprap Bedding

1. Mean stone size

Test	Test Method	Requirements	
Resistance to Degradation (%)	ASTM C131 or C535 ⁽¹⁾⁽³⁾	45 Maximum	
Absorption (%)	ASTM C127 ⁽³⁾	4 Maximum	
Apparent Specific Gravity	ASTM C127 ⁽³⁾	2.5 Minimum ⁽²⁾	
Durability	ASTM C3744 ⁽³⁾	52 Minimum	

Table 2- Aggregate Quality Requirements

(1) 500 Revolutions

(2) Riprap with a specific gravity of less than 2.5 may be provided for use outside of channels and major drainage facilities if approved by the Engineer.

(3) Tests performed on a processed sample of parent rock.

CONSTRUCTION METHODS

752-3.1 Unclassified excavation.

a. Trenches and foundation pits for structures or structure footings shall be excavated to the lines and grades and elevations shown on the plans. The excavation shall be of sufficient size to permit the placing of the full width and length of the structure or structure footings shown. The elevations of the bottoms of footings, as shown on the plans, shall be considered as approximate only; and the Engineer may approve, in writing, changes in dimensions or elevations of footings necessary to secure a satisfactory foundation.

b. Boulders, logs, or any other objectionable material encountered in excavation shall be removed. All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface either level, stepped, or serrated, as directed by the Construction Manager. All seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed. When concrete will rest on a surface other than rock, the bottom of the excavation shall not be disturbed and excavation to final grade shall not be made until immediately before the concrete or reinforcing steel is placed.

c. The Contractor shall do all bracing, sheathing, or shoring necessary to perform and protect the excavation and the structure as required for safety or conformance to governing laws. The cost of bracing, sheathing, or shoring shall be included in the unit price bid for excavation.

d. All bracing, sheathing, or shoring shall be removed by the Contractor after the completion of the structure. Removal shall not disturb or damage the finished concrete. The cost of removal shall be included in the unit price bid for excavation.

e. After each excavation is completed, the Contractor shall notify the Construction Manager. No concrete or reinforcing steel shall be placed until the RPR has approved the depth of the excavation and the character of the foundation material.

752-3.2 Backfilling.

a. After a structure has been completed, backfilling with approved material shall be accomplished by applying the fill in horizontal layers not to exceed 8 inches (200 mm) in loose depth, and compacted. The field density of the compacted material shall be at least 90% of the maximum density for cohesive soils

and 95% of the maximum density for noncohesive soils. The maximum density shall be determined in accordance with ASTM D698. The field density shall be determined in accordance with ASTM D1556.

b. No backfilling shall be placed against any structure until approved by the Construction Manager. For concrete, approval shall not be given until the concrete has been in place seven (7) days, or until tests establish that the concrete has attained sufficient strength to withstand any pressure created by the backfill or the placement methods.

c. Fill placed around concrete culverts shall be deposited on each side at the same time and to approximately the same elevation. All slopes bounding or within the areas to be backfilled shall be stepped or serrated to prevent wedge action against the structure.

d. Backfill will not be measured for direct payment. Performance of this work shall be considered as a subsidiary obligation of the Contractor, covered under the contract unit price for "unclassified excavation for structures."

752-3.3 Weep holes. Weep holes shall be constructed as shown on the plans.

752-3.4 Cleaning and restoration of site. After the backfill is completed, the Contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankment, shoulders, or as approved by the Construction Manager. The Contractor shall restore all disturbed areas to their original condition. The Contractor shall remove all tools and equipment, leaving the entire site free, clear, and in good condition.

METHOD OF MEASUREMENT

752-4.1 Headwalls shall be measured by each headwall completed in place and accepted.

752-4.2 The quantity for rip rap apron will be measured by the square foot for rip rap, by class, installed and accepted.

BASIS OF PAYMENT

752-5.1 The accepted quality for headwall will be paid for at the contract unit price per each in place and accepted. The price shall be full compensation for furnishing all materials and for all preparation, excavation, backfilling and placing of the materials; furnishing and installation of such specials, rebar, trash rack, and connections to pipes and other structures as may be required to complete the item as shown on the plans; and for all labor equipment, tools and incidentals necessary to complete the structure.

752-5.2 Payment for rip rap (class) will be made at the contract unit price per square foot. This price shall be full compensation, including Contractor overhead and profit, for furnishing all materials and for all preparation including dewatering, excavation, backfilling, bedding, materials, labor, equipment, and any incidentals necessary to complete the item as shown on the plans.

Payment will be made under:

Item D-752-1	Install Dual 30" Headwall– per each
Item D-752-2	Install Dual 30" Headwall with Access Control Grate – per each
Item D-752-3	Install 29"x45" Flared End Section w/ Access Control Grate
Item D752-4	Install Rip Rap (Class 150) – per square foot
Item D752-5	Install Rip Rap (Class 300) – per square foot

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft ³ (600 kN-m/m ³))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

END OF ITEM D-752

ITEM T-908 MULCHING

DESCRIPTION

908-1.1 This item shall consist of furnishing, processing, hauling, placement, and compacting either crushed Portland Cement Concrete removed from existing paved areas or coarse aggregate to prepared areas in the infield as indicated on the plans or as directed by the Construction Manager.

MATERIALS

908-2.1 Material. Acceptable soil stabilization material shall be crushed Portland Cement Concrete removed from other work on the Airport provided deformed or smooth steel dowel or tie bars are removed or imported crushed stone.

The gradation shall be in accordance with the following table:

Sieve Size	Percent Passing by Weight
3 inch	100
1 inch	20-55
No. 4	0-25

CONSTRUCTION METHODS

908-3.1 Mulching. Before placing surface rock material, area to be stabilized shall be proof rolled to nonyielding surface. Place crushed concrete at the thickness and to the line and grade indicated on the plan. After placing mulch material, roll with a steel drum roller of sufficient weight to seat the crushed material. Ensure that any steel bars remaining do not protrude from the surface.

908-3.2 Preparation for Surface Rock placement on native ground. Prior to the placement of surface rock or commencement of grading operations the Contractor shall remove existing vegetation (clear and grub) by mowing and an application of a non-selective pre-emergent herbicide or by scalping of the top 2 inches of the surface. Surface rock placement shall be completed per section T-908.

METHOD OF MEASUREMENT

908-4.1 For "Import and Place Surface Rock", measurement shall be by the square yard (square meter), at the designated thickness, as indicated in the Owner's estimate. The area to be paid for will be calculated on the basis of the dimensions shown on the contract drawings or as adjusted by the amount of any changed ordered by the Owner to include surface rock restoration area which exceeds the area included under the "Remove, Stockpile, and Reset Surface Rock." item. No allowance will be made for material outside said dimensions unless ordered by the Owner.

BASIS OF PAYMENT

908-5.1 For "Import and Place Surface Rock" payment shall be made at the contract unit price per square yard (square meter) at the thickness shown. This price shall be full compensation including Contractor overhead and profit for furnishing all materials, labor, equipment, tools, surface preparation, and incidentals necessary to complete the item.

Payment will be made under:

Item T-908-1	Remove, Stockpile, and Reset Existing Surface Rock (3"-6" thick)
Item T-908-2	Import and Place Surface Rock (3" thick) – per square yard (square meter)
Item T-908-3	Clear and Grub – per square yard (square meter)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM D977 Standard Specification for Emulsified Asphalt

Advisory Circulars (AC)

AC 150/5200-33 Hazardous Wildlife Attractants on or Near Airports

FAA/United States Department of Agriculture

Wildlife Hazard Management at Airports, A Manual for Airport Personnel

END OF ITEM T-908

ITEM L-100 LIGHTING AND ELECTRICAL WORK

DESCRIPTION

100-1.1 GENERAL. The airfield electrical work to be done under this contract shall include the furnishing of all supervision, labor, materials, tools, equipment, and incidentals necessary to provide new airfield lighting system and other electrical work as shown on the drawings.

The electrical work shall comply with latest adopted editions, codes and standards applicable to this Contract as follows:

ICEA	Insulated Cable Engineers Association
ANSI C2	National Electrical Safety Code
ASTM	American Society of Testing and Materials
FAA	Advisory Circulars
FAA	Engineering Briefs
FAA	Orders
NECA	Standard for Installation
NEMA	Standard for Materials and Products
NFPA	National Electrical Code, 70
NFPA	Standard for Electrical Safety in the Workplace, 70E
NFPA	Life Safety Code, 101
OSHA	Occupational Safety and Health Administration, as Amended
UL	Underwriters Laboratories

All work shall be performed in strict accordance with these contract specifications, drawings, and any instructions that may be furnished by the Construction Manager during execution of the work to aid in interpretation of said drawings and specifications. Installation details and material and equipment specifications shall be in conformance with all applicable FAA Advisory Circulars, Orders and Engineering Briefs. The Contractor shall furnish written proof of FAA approval on all equipment covered by FAA specifications as part of the submittal package. The Contractor shall keep these specifications on file at their airport construction office.

100-1.2 RELATED DOCUMENTS. The general provisions of the contract apply to the work specified in Items L-100, L-108, L-110, and L-125.

100-1.3 SUMMARY OF WORK. The work to be performed includes furnishing all labor, supplies, materials, equipment, transportation, and services required to augment, move, install, and complete electrical work as specified herein and as shown on the contract drawings.

The work includes, but is not limited to, the following:

a. Maintain in operation, all existing field electrical facilities and circuits while this improvement work is in progress, including protection of airport personnel, aircraft, and vehicles; furnish and maintain temporary circuits, and place augmented airport lighting into operation. Field lighting shall be operable each night, each day when fog conditions exist, when the airport calls an emergency, or whenever the lighting system is deemed critical for use by Airport Operations or the FAA for safe operations of the airfield.

b. Provide underground cable (L-824) in accordance with specifications, at the locations shown on the plans. Test all circuit loops before and after installation of new cables to verify that no damage was caused by the Contractor.

c. Equipment list: Equipment includes, but not limited to: Conduit, ductbank, cable, connectors, base cans, handholes, panelboards, fixtures, transformers, wind cones, RPUs, R I/Os, CCRs, testing, commissioning and all necessary equipment to maintain and perform work on electrical facilities.

d. Return to Owner or remove from the site, as directed by the Construction Manager, existing equipment that is to be removed or replaced.

e. Ground all equipment, enclosures, and conduits installed under this contract as shown on the plans, specifications or in accordance with the NEC whichever is more stringent.

f. Adjust finished grade as necessary to accommodate existing and new airfield equipment.

g. Other items required to complete foregoing. The omission of expressed reference to any parts necessary for or reasonably incidental to the complete installation shall not be construed as releasing the Contractor from furnishing and installing such parts.

h. In P-501 panel removal, asphalt removal or grading areas, the counterpoise conductor shall be tested prior to any work. The resistive value shall be documented and provided to the Construction Manager. At the completion of panel placement, the counterpoise shall be measured to be less than or equal to the value measured prior to demolition and witnessed by the Construction Manager. Counterpoise conductors shall be found to be continuous based on the resistive value (size and length) between locations such as light can to light can, manhole to light can, manhole to manhole, light can to ground rod, etc. Measurements shall be completed and demonstrated to the Construction Manager or designated representative before work is to proceed. Non-continuous counterpoise conductors shall be subject to removal of completed work and counterpoise repaired at no additional cost to the owner.

i. The Contractor shall inspect the conduit system prior to paving to assure the conduit is not damaged. The Contractor shall use an approved mandrel to proof the conduit system that runs through any panel replacement area; once panel replacement is completed the conduit shall have a mandrel pulled through the duct prior to re-installation of cable.

All items of general work required, such as excavation, cutting, patching, etc. shall be included in this Contract.

100-1.4 WORK REQUIREMENTS. The general work requirements are as follows:

- All work shall be scheduled to minimize the impact and duration of runway or taxiway shutdowns. The Contractor shall keep the Construction Manager informed of scheduled work which will affect existing equipment and operations. Minimum 10 working days advance notice shall be given to the Construction Manager and approval received for any disconnections or shutdowns.
- Existing lighting systems shall be operational at the end of each working day prior to nightfall except as permitted by the Construction Manager. Poor weather visibility or an emergency situation may require postponement of a scheduled shutdown on any given day.
- The plans are diagrammatic. Locations of equipment to be installed are shown in the plans, but the actual installation will depend on field conditions and the nature of the equipment furnished. When conditions which will adversely affect the installation become apparent, the Construction Manager shall be notified in writing.
- Locations and quantities of materials shown on the plans and in these specifications are approximate and shall be used for estimating purposes only. Actual locations and quantities of materials shall be reviewed by the Contractor through field investigation. No additional payment will be made for discrepancies between estimated quantities and locations of materials as shown in these documents and the actual field conditions.

The Contractor shall at all times keep the construction areas free from accumulations of waste material and rubbish, and prior to completion of work shall remove any rubbish from the project, as well as all tools, reels, equipment, and materials not a part of the project. Upon completion of the construction, the Contractor shall leave the work and premises in a clean, neat, and safe condition satisfactory to the Construction Manager. The Contractor shall be responsible for the proper performance in all respects, in whole and in part, of the electrical equipment and for the mechanical installation of electrical equipment until acceptance of the entire work by the Construction Manager.

100-1.5 SUBMITTALS. Submittals of all equipment and materials shall meet the requirements of Section 013300, Section 013325 and in accordance with this specification. Each submittal shall include no more than one spec section, i.e., each spec section shall be submitted under a separate submittal form as per Section 013300.

All materials and equipment used to construct this project shall be submitted to the Construction Manager for approval prior to ordering the equipment. Indicate all optional equipment and delete non-pertinent data. The Contractor is solely responsible for project delays accruing directly or indirectly from late submissions or resubmissions of submittals. This book shall include all fixtures and appropriate incidentals for each fixture to indicate to the Construction Manager that the Contractor comprehends the airfield lighting installation process.

The Contractor shall include wiring diagrams, cut sheets, brochures, etc. of all equipment used on the job, including, but not limited to the items listed in these specifications and in the format described herein. The submittal package will not be reviewed unless 100% complete.

The submittal shall consist of manufacturer's brochures and cut sheets describing the equipment and materials the Contractor plans to incorporate in the work. These sheets shall be sequentially ordered by specification number with the reference specification number shown on the bottom right of each sheet. Each cut sheet shall show the complete specification or drawing number with which the item must comply (i.e., L-108.2.03 and/or detail 3 on page EL-501). Clearly and boldly mark each copy to identify pertinent products or models applicable to this project.

In the one bound book, the cut sheets shall be organized by the specification item number (L-100, L-108, etc.) with a tabbed divider sheet separating each item section. The submitted cut sheet shall clearly show the equipment manufacturer's name, catalog number, size, type, and/or rating as required by these specifications or drawings by underlining or circling the information, highlighting is not acceptable. The conformance to FAA criteria or other standards where called for shall be clearly indicated for each item. Each sheet shall be dedicated to one piece of equipment, and all sheets shall be sequentially numbered (i.e., 1/50; indicating page 1 of 50 total pages). One manufacturer's cut sheet shall be submitted for each item. All sheets shall be 8-1/2" x 11" or 17" x 11". When these sizes are unpractical, a folded 24" x 36" drawing may be substituted. All drawings shall be to scale. All sheets shall be bound in a 3-ring binder. Each submittal shall show on the cover the complete job name and number, date, Contractor's name, and the words: "Electrical Submittal." The checklist shown in this specification shall be included as the first sheet of each submittal and shall show the page number of each item included in the submittal. Additional items to be submitted which are not on the list shall be added to the bottom of the table.

Samples of conduit, duct, fittings, cables, tapes, fixtures, etc., may be requested by the Construction Manager or required in these specifications. After they have been reviewed, samples will be returned in tested condition to the Contractor. In the event any items of material or equipment contained in the list fail to comply with specification requirements, such items will be rejected. All rejected items shall be amended to meet the criteria and then resubmitted for approval by the Construction Manager.

Substitutions of materials referenced herein is allowed when "or equal" is referenced. Any substitution shall be included in the submittal package and contain additional information as required by Section 016000.

All methods and shop drawings of installations shall be submitted and approved prior to the start of installation for each phase of work.

Contractor's liability to the City, in case of variations in the submittal document from the requirements of the contract documents is not relieved by the City's review and acceptance of submittals containing variations unless the City expressly approves the deviations in writing, in which the City describes the variation.

100-1.6 DRAWINGS. The plans, which constitute an integral part of this Contract, shall serve as the working drawings. They indicate the extent and general layout of the lighting and signing system, arrangement of circuits, cables through ducts, and connections to existing circuit cables, and other work. Field verification of scale dimensions is required to determine actual locations, distances, and levels. The Contractor shall research in the field the exact routing and identification of all circuits which extend through, serve, or are affected by the area where work is to commence. No extra compensation will be allowed because of minor differences between work shown on the drawings and field conditions. The Contractor shall check the plans and specifications and, if any portion of the work is found to be omitted, unclear, or in error, the Contractor shall immediately notify the Construction Manager. The directions of the Construction Manager shall be followed and the work completed accordingly. The design drawings may be utilized in the preparation of the shop or working drawings showing the permanent construction, as described in L-100.

The plans and specifications are complementary and what is called for in either one shall be as binding as if called for in both.

Where a disagreement exists between the plans and specifications, the item or arrangements of better quality, greater quantity, or higher cost shall be included in the bid.

Any discrepancies between the drawings, Advisory Circulars, and field conditions must be resolved with the Construction Manager before proceeding. All agreements shall be verified in writing.

'Record' drawings covering equipment installed under previous contracts and which relate to this contract will be available for the Contractor. The airport cannot, however, guarantee the accuracy of these drawings. Those conditions which will affect the work under this contract should be verified prior to any design/fabrication/installation commitment.

Detail dimensions shown on the plans are approximate and shall be field verified before construction. All differences shall be submitted to the Construction Manager in writing before construction begins.

100-1.7 RECORD DRAWINGS. The Contractor shall mark up a set of blue line prints to show the as-built conditions which differ from the contract plans. All changes shall be recorded by a skilled draftsman with at least three years of CAD experience. The Construction Manager will furnish a newly printed set of blueline drawings to be used for this purpose. Record drawings will be checked periodically for accurateness and partial payments will be withheld until the record drawings are completely updated. The mark-up set shall be kept at the site, and any changes, discoveries, or deviations shall be recorded daily. The Contractor shall furnish one newly printed as-built drawing set to the Construction Manager upon completion. This work shall be completed and accepted by the Construction Manager before approval of final payment. The Contractor shall include complete asbuilt drawings with Northing/Easting coordinates and elevations of duct banks installed. The Contractor shall document all return splice locations and complete wiring diagrams including the actual field configuration of circuits.

100-1.8 MAINTENANCE AND OPERATING INSTRUCTIONS. The Contractor shall provide the Owner with complete instructions in the proper care and operation of the equipment installed under this contract. This is considered as part of the final inspection, and final acceptance will not be given until the Owner's representative is knowledgeable about the system.

The Contractor shall also collect and assemble into each of three hardcover books and three CDs the installation details, instructions, parts list, source of local supply, schematics of actual equipment and operations, and directions supplied by the manufacturer with all equipment. If cut sheets are included showing various models and features of the equipment supplied, the specific model and features shall be clearly indicated to show only the options of the equipment that are actually provided and installed. Final acceptance of the work will be withheld until such data has been presented complete to the Construction Manager for transmission to the Owner. The Contractor shall comply with Section 017825 Operation and Maintenance Data.

The Contractor shall install all equipment according to the manufacturers' instructions and as shown in the drawings and specifications. The Contractor shall notify the Construction Manager in writing if any discrepancies exist between the aforementioned documents. Work shall be suspended until resolved and approval to proceed has been granted by the Construction Manager.

100-1.9 SAFETY RULES. The Electrical Safety Rules shall be observed and complied with in every detail, and any violation thereof shall be cause for immediate termination of the Contractor's authority to proceed with the work and recourse to their Surety for completion of the Project. The Electrical Safety Rules are as follows:

The Contractor shall be responsible for conforming to the safety requirements of AC 150/5370-2, AC 150/5340-30, NFPA/NEC, as well as local building and electrical codes.

Electrical circuits, operating over 300 volts, phase-to-ground shall be de-energized before work is accomplished thereon. Work on energized systems shall be accomplished by trained personnel, properly insulated, and done with extreme caution.

Electrical circuits shall be considered de-energized only when one of the following conditions exists:

- Switches connecting subject circuit to the electrical supply are observed in the OPEN position, with an air break, and safety-tagged (padlocked) in the OPEN position;
- Electrically operated switches are visibly OPEN, blocked or racked in the OPEN position, and safety-tagged OPEN;
- Whenever the supply circuit breaker is not visible and clearly identified, the circuit shall be grounded. The ground connection shall be safety-tagged before work thereon, when the ground connection is not within sight of the work area.
- Oil switches observed OPEN in a sight window, and tagged OPEN; or oil fuse cutouts with fuse carrier removed and tagged OPEN.
- For airfield lighting circuits fed by constant current regulators, the disconnect switches feeding all affected regulators and power circuits leaving the vault shall be locked in the OPEN position. When working in manhole housings, additional circuits not a part of the project, those circuits shall be locked in the OPEN position as well. The circuits shall be put into maintenance lock out on the control system with the assistance of the Construction management team prior to lock out of the regulator.

a. Use of Red Safety Tags: Safety tags shall be filled out daily and connected to any switch or equipment opened for protection of personnel working upon circuits connected thereto.

Safety tags shall be removed only by the employee who placed the tag, or by another employee designated in writing by the employee who placed the tag, to remove the tag. Removal of a safety tag placed by an employee not available at the time of need to remove may be authorized by the Electrical Superintendent or his designated representative, only after carefully checking that the circuit is ready to be energized.

Equipment with a safety tag attached shall not be operated, and connections with a safety tag attached shall not be changed.

Insulated cables, operated at over 300 volts to ground shall be handled, when energized, only with rubber gloves tested to 15,000 volts.

Insulated cables, which have been in operation, shall be cut only with grounded cable shears, or shall be grounded by driving a grounded sharp tool through the shielding and the conductors before cutting.

All personnel working around energized electrical equipment operating at over 600 volts shall wear standard insulated, non-conducting hard hats, and shall wear no garments with metallic zipper fasteners, and remove all jewelry.

Ladders used in any electrical work shall be of wood or fiberglass construction.

The Contractor shall designate a supervisor for all contract personnel and operations; said supervisor shall be present at the job site wherever contract operations are in progress.

EQUIPMENT AND MATERIALS

100-2.1 GENERAL. Airport lighting equipment and materials covered by Federal Aviation Administration (FAA) specifications shall be certified by independent laboratory testing to be in compliance with the specification, at the date of the Contractor's bid submission.

Equipment and materials covered by other referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification when requested by the Construction Manager. Whenever Underwriters Laboratories has a published standard applicable to the equipment furnished for this contract, the furnished equipment shall be listed by UL. The term 'Equipment' shall be as defined in the NEC.

Materials and equipment shall be as specified herein. When materials are used that are not specifically designated herein, they shall be in accordance with the best industry standards and practices for equipment of this type. All components and parts shall be suitable for operation under the environmental conditions specified herein. Metal parts shall be either inherently corrosion-resistant or shall be suitably protected to resist corrosion or oxidation during extended service life.

100-2.2 HARDWARE AND CORROSION PROTECTION. In order to prevent deterioration due to corrosion, all bolts, nuts, studs, washers, pins, terminals, springs, hangers and similar fastenings and fittings shall be of an approved corrosion-resisting material and/or be treated in an approved manner to render it adequately resistant to corrosion. All hardware such as cap screws, set screws, tap bolts, nuts, washers, etc., shall be of stainless steel type 304, SAE grade 2, if they are used outdoors unless specified otherwise on the plans. Brass, bronze, or hot-dip galvanized ferrous hardware (per ASTM, Specification A1530) will be considered for indoor use. All stainless steel and galvanized steel bolts, screws, nuts, etc., shall be coated with a layer of anti-seize compound.

All ferrous metalwork shall be hot-dip galvanized. If any galvanizing is damaged, the metal work shall be refinished by cleaning, treating with one coat of wash primer conforming to Federal (military) Specification MIL-P-152388, and shall be given one shop coat of zinc-rich base paint (zinc dust paint) conforming to Federal Specification TT-P-641F Type II, immediately when the wash primer is dry.

100-2.3 PARTS RATING. All parts shall be of adequate rating for the application and shall not be operated above the parts manufacturer's recommended ratings.

100-2.4 ENVIRONMENTAL CONDITIONS. The equipment installed outdoors shall be designated for continuous outdoor operation under the following environmental conditions unless specified elsewhere:

- **a.** Temperature: any ambient temperature from minus 20° F to plus 120° F.
- **b.** Altitude: 6000 MSL.
- **c.** Humidity: up to 100 percent.

- **d.** Sand and Dust: exposure to windblown sand and dust particles.
- e. Wind: operation at wind velocities up to 200 miles per hour.

f. Water: components provided for underground installation, direct buried or installed in underground housing, shall be suitable for continuous operation, continuously or intermittently submerged in water.

g. Chemical: shall be rated for exposure to all de-icing and anti-icing agents.

100-2.5 SALVAGE. Except as otherwise specified or indicated on the drawings, all electrical materials and equipment to be salvaged, removed, or "stored" shall become the property of the airport, and shall be moved by the Contractor to a site at the airport or within 5 miles of the airport designated by the Construction Manager. All wastes such as removed asphalt, concrete, excess dirt, conductors, damaged base cans, etc., shall become property of the Contractor and shall be disposed of off site by the Contractor.

100-2.6 TESTING. All materials and finishes are subject to testing. Material inspection and testing, and strength tests on the concrete will be performed by the Contractor at no expense to the airport other than material used. The Contractor shall assist the Construction Manager in obtaining samples during the course of construction work. The testing of electrical equipment shall conform to the description of the individual specification sections.

100-2.7 INSPECTION. Provide for electrical inspections by the Construction Manager. No work shall be concealed or enclosed until after inspections. If work is concealed or enclosed without inspection and approval, the Contractor shall be responsible for all expense and work required to open and restore the concealed area in addition to all required modifications.

Mill inspection will be waived, and the materials accepted upon certified copies of mill reports identifying the material specification requirements. Copies of order bills and test reports shall be furnished as requested.

100-2.8 WARRANTY. The Contractor shall provide a written 2-year warranty guaranteeing all work installed under this contract. It shall cover all parts and labor against defective parts, corrosion or workmanship necessary to repair or bring into proper operation any equipment including, but not limited to, isolation transformers, lamps, inset and elevated lighting fixtures, poles, conduit system, and junction boxes. This warranty work includes the Contractor to be on-site to remove, replace and ship any defective equipment discovered during the warranty period. At the end of the 2-year warranty period, the insulation resistance of each circuit shall be measured to a minimum of 750 Mohms according to the testing requirements per Item L-108. The warranty shall start upon the final acceptance of all work as accepted by the Construction Manager. Final payment will be withheld until receipt of the warranty by the Construction Manager.

LED fixtures shall have a written 4 year warranty provided as required by FAA Engineering Brief 67 (latest edition).

CONSTRUCTION METHODS

100-3.1 GENERAL. Installation shall be performed by experienced and skilled persons to obtain only the best workmanship. All equipment shall be set square and true with construction. The work shall be under constant supervision by the Contractor, or by an authorized and competent

foreman with five years airfield experience, until completion. The installation and adjustments shall be by competent Colorado State recognized licensed journeyman electricians. The Contractor shall include no more than one certified apprentice per journeyman electrician. Apprentices shall be under the direct supervision of a licensed electrician at all times.

All work shall be inspected by the Contractor's electrical QC. The electrical QC shall be responsible to correct or stop work when items of installation are found not to the contract documents. The number of inspectors shall be adequate to cover all work areas during all phases of construction. The electrical QC inspector shall be submitted under the electrical QC Manager Plan.

100-3.2 INSTALLATION METHOD. The methods used for the installation of electrical system and equipment shall conform to the National Electric Contractors Association (NECA) published "Standard of Installation" except where specifically specified or shown otherwise, and to the requirements of the National Electrical Code (NEC) and its revisions.

All electrical materials, construction methods, and installation shall be in accordance with applicable Federal Aviation Administration's advisory circulars including amendments, the National Electrical Code, and the American National Standards Institute Standard C2.

Workmanship shall be consistent with the best commercial practices for installation of this type. The workmanship shall be first class and in accordance with the highest standards of the electrical industry.

The responsibility for the correct and satisfactory installation and operation of all materials and equipment required herein shall rest with the Contractor. Before any equipment is ordered, a complete schedule of materials and detailed shop drawings covering all items of equipment and brochures of the materials proposed for installation shall be submitted for approval by the Construction Manager as described in Item L-100.

100-3.3 SITE CONDITIONS. At least five working days prior to commencing construction operations in an area which may involve underground utility facilities, the Contractor shall notify the Construction Manager and the owners of each underground utility facility shown on the plans. The FAA will assist the Contractor in locating FAA cables.

The existence of any known buried wires, conduits, junction boxes, ducts, or other facilities is shown in a general way only. It will be the duty of the Contractor, with the help of airport personnel, to visit the site and make exact determination of the existence and location of any facilities prior to commencing any work. It is understood that the Contractor will be responsible for making the exact determination of the location and condition of such facilities. Any costs shall be paid for by the Contractor. The Contractor shall obtain from the Construction Manager copies of contract drawings from previous construction projects, and examine these drawings and verify at the site the location of all below grade utilities in the vicinity of the work performed under this contract.

All items damaged by the Contractor's workers or equipment shall be replaced immediately at the Contractor's expense.

100-3.4 INTERRUPTIONS. Interruptions of lighting circuits may be necessary during construction. The Contractor shall provide a reliable shunt cable to provide temporary continuity of circuit service to runway and taxiway lights and signs during construction where required. The Contractor shall not interrupt any circuit or perform any work that might endanger any circuit until

approval of the Construction Manager has been received. Temporary cables shall be installed in conduit and identified as a hazard.

The Contractor shall be responsible for installing, maintaining, protecting, and removing all required temporary jumper cables used to maintain power to electrical circuits.

For the permanent installation, all temporary connections and rerouting of circuits shall be replaced with new materials installed in accordance with the specifications and as shown on the plans.

See Item L-100, paragraph SAFETY RULES. Payment for this work will be made under Item L-108, Temporary Electrical Work/Jumpers when indicated. Otherwise the work shall be considered incidental.

If requested by the Construction Manager, Contractor shall submit for approval an Operational Safety Plan (OSP) including circuits to be locked off and signs to be covered during construction.

100-3.5 CODES. The Contractor shall comply with all ordinances, laws, regulations, and codes applicable to the work involved and as referenced in these specifications. This does not relieve the Contractor from furnishing and installing work shown or specified which may be beyond the requirements of such ordinances, laws, regulations, and codes.

100-3.6 SAFETY AREA. The Contractor shall abide by the requirements of the contract specifications when working within the runway or taxiway safety areas or as directed by the Construction Manager.

METHOD OF MEASUREMENT

100-4.1 Electrical General Requirements. The electrical general requirements shall be incidental to the work or incorporated in other pay items, with no separate measurement or payment.

MATERIAL REQUIREMENTS

AC 150/5370-2	Operational Safety on Airports During Construction
AC 150/5370-10	Standards for Specifying Construction of Airports
MIL-P-152388	Wash Primer Specification
TT-P-641F	Type II, Base Paint, Zinc-Rich

END OF ITEM L-100

ITEM L-108 UNDERGROUND POWER CABLE FOR AIRPORTS

DESCRIPTION

108-1.1 This item shall consist of furnishing and installing power cables that are direct buried and furnishing and/or installing power cables within conduit or duct banks per these specifications at the locations shown on the plans. It includes excavation and backfill of trench for direct-buried cables only. Also included are the installation of counterpoise wires, ground wires, ground rods and connections, cable splicing, cable marking, cable testing, and all incidentals necessary to place the cable in operating condition as a completed unit to the satisfaction of the RPR. This item shall not include the installation of duct banks or conduit, trenching and backfilling for duct banks or conduit, or furnishing or installation of cable for FAA owned/operated facilities such as MALSR which is bid separately.

EQUIPMENT AND MATERIALS

108-2.1 GENERAL.

a. Airport lighting equipment and materials covered by advisory circulars (AC) shall be approved under the Airport Lighting Equipment Certification Program per AC 150/5345-53, current version.

b. All other equipment and materials covered by other referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification, when requested by the RPR.

c. Manufacturer's certifications shall not relieve the Contractor of the responsibility to provide materials per these specifications. Materials supplied and/or installed that do not comply with these specifications shall be removed (when directed by the RPR) and replaced with materials that comply with these specifications at the Contractor's cost.

d. All materials and equipment used to construct this item shall be submitted to the RPR for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Submittal data shall be presented in a clear, precise and thorough manner. Original catalog sheets are preferred. Photocopies are acceptable provided they are as good a quality as the original. Clearly and boldly mark each copy to identify products or models applicable to this project. Indicate all optional equipment and delete any non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment to which they apply on each submittal sheet. Markings shall be made bold and clear with arrows or circles (highlighting is not acceptable). The Contractor is solely responsible for delays in the project that may accrue directly or indirectly from late submissions or resubmissions of submittals.

e. The data submitted shall be sufficient, in the opinion of the RPR, to determine compliance with the plans and specifications. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Submittal data shall be presented in a clear, precise and thorough manner. Original catalog sheets are preferred.

Photocopies are acceptable provided they are as good a quality as the original. Clearly and boldly mark each copy to identify products or models applicable to this project. Indicate all optional equipment_and delete any non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment to which they apply on each submittal sheet. Markings shall be made bold and clear with arrows or circles (highlighting is not acceptable). The Contractor is solely responsible for delays in the project that may accrue directly or indirectly from late submissions or resubmissions of submittals. The RPR reserves the right to reject any and all equipment, materials, or procedures that do not meet the system design and the standards and codes, specified in this document.

f. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for at least (24) months from the date of final acceptance by the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner. The Contractor shall maintain a minimum insulation resistance in accordance with paragraph 108-3.10e with isolation transformers connected in new circuits and new segments of existing circuits through the end of the contract warranty period when tested in accordance with AC 150/5340-26, *Maintenance Airport Visual Aid Facilities*, paragraph 5.1.3.1, Insulation Resistance Test.

108-2.2 CABLE. Underground cable for airfield lighting facilities (runway and taxiway lights and signs) shall conform to the requirements of AC 150/5345-7, Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits latest edition. Conductors for use on 6.6 ampere primary airfield lighting series circuits shall be single conductor, seven strand, #8 American wire gauge (AWG), L-824 Type C, 5,000 volts, non-shielded, with cross-linked polyethylene insulation.

L-824 conductors for use on the L-830 secondary of airfield lighting series circuits shall be sized in accordance with the manufacturer's recommendations. All other conductors shall comply with FAA and National Electric Code (NEC) requirements. Conductor sizes noted above shall not apply to leads furnished by manufacturers on airfield lighting transformers and fixtures.

Wire for electrical circuits up to 600 volts shall comply with Specification L-824 and/or Commercial Item Description A-A-59544A and shall be type THWN-2, 75°C for installation in conduit and RHW-2, 75°C for direct burial installations. Conductors for parallel (voltage) circuits shall be type and size and installed in accordance with NFPA-70, National Electrical Code.

Unless noted otherwise, all 600-volt and less non-airfield lighting conductor sizes are based on a 75°C, THWN-2, 600-volt insulation, copper conductors, not more than three single insulated conductors, in raceway, in free air. The conduit/duct sizes are based on the use of THWN-2, 600-volt insulated conductors. The Contractor shall make the necessary increase in conduit/duct sizes for other types of wire insulation. In no case shall the conduit/duct size be reduced. The minimum power circuit wire size shall be #12 AWG.

Conductor sizes may have been adjusted due to voltage drop or other engineering considerations. Equipment provided by the Contractor shall be capable of accepting the quantity and sizes of conductors shown in the Contract Documents. All conductors, pigtails, cable step-down adapters, cable step-up adapters, terminal blocks and splicing materials necessary to complete the cable termination/splice shall be considered incidental to the respective pay items provided.

Cable type, size, number of conductors, strand and service voltage shall be as specified in the Contract Document.

108-2.3 BARE COPPER WIRE (COUNTERPOISE, BARE COPPER WIRE GROUND AND GROUND RODS). Wire for counterpoise or ground installations for airfield lighting systems shall be No. 6AWG solid copper or No. 1/0 bare stranded copper wire for counterpoise and/or No. 6AWG insulated stranded for grounding bond wire per ASTM B3 and ASTM B8, and shall be bare copper wire. For voltage powered circuits, the equipment grounding conductor shall comply with NEC Article 250.

Ground rods shall be copper steel clad. The ground rods shall be of the length and diameter specified on the plans, but in no case be less than 10 feet long and ³/₄"in diameter.

108-2.4 CABLE CONNECTIONS. In-line connections or splices of underground primary cables shall be of the type called for on the plans, and shall be one of the types listed below. No separate payment will be made for cable connections.

a. The cast splice. Not Used.

b. The field-attached plug-in splice. Field attached plug-in splices shall be installed as shown on the plans. The Contractor shall determine the outside diameter of the cable to be spliced and furnish appropriately sized connector kits and/or adapters. Tape or heat shrink tubing with integral sealant shall be in accordance with the manufacturer's requirements. Primary Connector Kits manufactured by Amerace, "Super Kit", Integro "Complete Kit", or approved equal is acceptable.

c. The factory-molded plug-in splice. Specification for L-823 Connectors, Factory-Molded to Individual Conductors, is acceptable.

d. The taped or heat-shrink splice. Not Used.

108-2.5 SPLICER QUALIFICATIONS. Every airfield lighting cable splicer shall be qualified in making airport cable splices and terminations on cables rated at or above 5,000 volts AC. The Contractor shall submit to the RPR proof of the qualifications of each proposed cable splicer for the airport cable type and voltage level to be worked on. Cable splicing/terminating personnel shall have a minimum of three (3) years continuous experience in terminating/splicing medium voltage cable.

108-2.6 CONCRETE. Concrete shall be proportioned, placed, and cured per Item P-610, Concrete for Miscellaneous Structures.

108-2.7 FLOWABLE BACKFILL. Flowable material used to backfill trenches for power cable trenches shall conform to the requirements of Item P-153, Controlled Low Strength Material.

108-2.8 CABLE IDENTIFICATION TAGS. Cable identification tags shall be made from a non-corrosive material with the circuit identification stamped or etched onto the tag. The tags shall be of the type as detailed on the plans.

108-2.9 TAPE. Electrical tapes shall be ScotchTM Electrical Tapes –ScotchTM 88 (1-1/2 inch (38 mm) wide) and ScotchTM 130C[®] linerless rubber splicing tape (2-inch (50 mm) wide), as manufactured by the Minnesota Mining and Manufacturing Company ($3M^{TM}$), or an approved equivalent.

108-2.10 ELECTRICAL COATING. Electrical coating shall be ScotchkoteTM as manufactured by $3M^{TM}$, or an approved equivalent.

108-2.11 EXISTING CIRCUITS. Whenever the scope of work requires connection to an existing circuit, the existing circuit's insulation resistance shall be tested, in the presence of the RPR.

The test shall be performed per this item and prior to any activity that will affect the respective circuit. The Contractor shall record the results on forms acceptable to the RPR. When the work affecting the circuit is complete, the circuit's insulation resistance shall be checked again, in the presence of the RPR. The Contractor shall record the results on forms acceptable to the RPR. The second reading shall be equal to or greater than the first reading or the Contractor shall make the necessary repairs to the existing circuit to bring the second reading above the first reading. All repair costs including a complete replacement of the L-823 connectors, L-830 transformers and L-824 cable, if necessary, shall be borne by the Contractor. All test results shall be submitted in the Operation and Maintenance (O&M) Manual.

108-2.12 DETECTABLE WARNING TAPE. Plastic, detectable, American Public Works Association (APWA) Red (electrical power lines, cables, conduit and lighting cable) with continuous legend tape shall be polyethylene film with a metalized foil core and shall be 3-6 inches (75-150 mm) wide. Detectable tape is incidental to the respective bid item. Detectable warning tape for communication cables shall be orange. Detectable warning tape color code shall comply with the APWA Uniform Color Code.

CONSTRUCTION METHODS

108-3.1 GENERAL. The Contractor shall install the specified cable at the approximate locations indicated on the plans. Unless otherwise shown on the plans, all cable required to cross under pavements expected to carry aircraft loads shall be installed in concrete encased duct banks. Cable shall be run without splices, from fixture to fixture.

Cable connections between lights will be permitted only at the light locations for connecting the underground cable to the primary leads of the individual isolation transformers. The Contractor shall be responsible for providing cable in continuous lengths for home runs or other long cable runs without connections unless otherwise authorized in writing by the RPR or shown on the plans.

In addition to connectors being installed at individual isolation transformers, L-823 cable connectors for maintenance and test points shall be installed at locations shown on the plans. Cable circuit identification markers shall be installed on both sides of the L-823 connectors installed and on both sides of slack loops where a future connector would be installed.

Provide not less than 3 feet (1 m) of cable slack on each side of all connections, isolation transformers, light units, and at points where cable is connected to field equipment. Where provisions must be made for testing or for future above grade connections, provide enough slack to allow the cable to be extended at least one foot (30 cm) vertically above the top of the access structure. This requirement also applies where primary cable passes through empty light bases, junction boxes, and access structures to allow for future connections, or as designated by the RPR.

Primary airfield lighting cables installed shall have cable circuit identification markers attached on both sides of each L-823 connector and on each airport lighting cable entering or leaving cable access points, such as manholes, hand holes, pull boxes, junction boxes, etc. Markers shall be of sufficient length for imprinting the cable circuit identification legend on one line, using letters not less than 1/4 inch (6 mm) in size. The cable circuit identification shall match the circuits noted on the construction plans.

108-3.2 INSTALLATION IN DUCT BANKS OR CONDUITS. This item includes the installation of the cable in duct banks or conduit per the following paragraphs. The maximum number and voltage ratings of cables installed in each single duct or conduit, and the current-carrying capacity of each cable shall be per the latest version of the National Electric Code, or the code of the local agency or authority having jurisdiction.

The Contractor shall make no connections or splices of any kind in cables installed in conduits or duct banks.

Unless otherwise designated in the plans, where ducts are in tiers, use the lowest ducts to receive the cable first, with spare ducts left in the upper levels. Check duct routes prior to construction to obtain assurance that the shortest routes are selected and that any potential interference is avoided.

Duct banks or conduits shall be installed as a separate item per Item L-110, Airport Underground Electrical Duct Banks and Conduit. The Contractor shall run a mandrel through duct banks or conduit prior to installation of cable to ensure that the duct bank or conduit is open, continuous and clear of debris. The mandrel size shall be compatible with the conduit size. The Contractor shall swab out all conduits/ducts and clean light bases, manholes, etc., interiors immediately prior to pulling cable. Once cleaned and swabbed, the light bases and all accessible points of entry to the duct/conduit system shall be kept closed except when installing cables. Cleaning of ducts, light bases, manholes, etc., is incidental to the pay item of the item being cleaned. All raceway systems left open, after initial cleaning, for any reason shall be re-cleaned at the Contractor's expense. The Contractor shall verify existing ducts proposed for use in this project as clear and open. The Contractor shall notify the RPR of any blockage in the existing ducts.

The cable shall be installed in a manner that prevents harmful stretching of the conductor, damage to the insulation, or damage to the outer protective covering. The ends of all cables shall be sealed with moisture-seal tape providing moisture-tight mechanical protection with minimum bulk, or alternately, heat shrinkable tubing before pulling into the conduit and it shall be left sealed until connections are made. Where more than one cable is to be installed in a conduit, all cable shall be pulled in the conduit at the same time. The pulling of a cable through duct banks or conduits may be accomplished by hand winch or power winch with the use of cable grips or pulling eyes. Maximum pulling tensions shall not exceed the cable manufacturer's recommendations. A non-hardening cable-pulling lubricant recommended for the type of cable being installed shall be used where required.

The Contractor shall submit the recommended pulling tension values to the RPR prior to any cable installation. If required by the RPR, pulling tension values for cable pulls shall be monitored by a dynamometer in the presence of the RPR. Cable pull tensions shall be recorded by the Contractor and reviewed by the RPR. Cables exceeding the maximum allowable pulling tension values shall be removed and replaced by the Contractor at the Contractor's expense.

The manufacturer's minimum bend radius or NEC requirements (whichever is more restrictive) shall apply. Cable installation, handling and storage shall be per manufacturer's recommendations. During cold weather, particular attention shall be paid to the manufacturer's minimum installation temperature. Cable shall not be installed when the temperature is at or below the manufacturer's minimum installation temperature. At the Contractor's option, the Contractor may submit a plan, for review by the RPR, for heated storage of the cable and maintenance of an acceptable cable temperature during installation when temperatures are below the manufacturer's minimum cable installation temperature.

Cable shall not be dragged across base can or manhole edges, pavement or earth. When cable must be coiled, lay cable out on a canvas tarp or use other appropriate means to prevent abrasion to the cable jacket.

108-3.3 INSTALLATION OF DIRECT-BURIED CABLE IN TRENCHES. Not Used.

108-3.4 CABLE MARKERS FOR DIRECT-BURIED CABLE. Not Used.

108-3.5 SPLICING. Connections of the type shown on the plans shall be made by experienced personnel regularly engaged in this type of work and shall be made as follows:

a. Cast splices. These shall be made by using crimp connectors for jointing conductors. Molds shall be assembled, and the compound shall be mixed and poured per the manufacturer's instructions and to the satisfaction of the RPR.

b. Field-attached plug-in splices. These shall be assembled per the manufacturer's instructions. These splices shall be made by plugging directly into mating connectors. The joint where the connectors come together shall be finished by one of the following methods: (1) wrapped with at least one layer of rubber or synthetic rubber tape and one layer of plastic tape, one-half lapped, extending at least 1-1/2 inches (38 mm) on each side of the joint (2) Covered with heat shrinkable tubing with integral sealant extending at least 1-1/2 inches (38 mm) on each side of the joint or (3) On connector kits equipped with water seal flap; roll-over water seal flap to sealing position on mating connector.

Factory-molded plug-in splices. Submit for review and acceptance the tools c. proposed for stripping and crimping of cable connections. Crimping tool shall be manufacture: Thomas and Betts, model # TBM45S or approved equal. Stripping tool shall be manufacture: Ripley Tool Company, model # WS-49 or approved equal. These shall be assembled per the manufacturer's instructions. Strip the insulation from the L-824 cable so the copper conductor is not damaged (ringed or nicked) in any way. Crimp conductors firmly in place with crimping tool that requires a complete crimp before tool can be removed. Crimp twice at 90° to each other. Test the crimped connection by pulling on the cable. After the cable is inserted into the rubber boot, the cable insulation and connector shall be cleaned with a wax and grease solvent to remove the silicone sealing grease from the cable surface. Ensure sand/debris does not enter the connector. Plug the mating connectors together and pull over the permanent molded sleeve at the interface. These splices shall be made by plugging directly into mating connectors. The Contractor shall not use mechanical means to pull flap over joint. In all cases the joint where the connectors come together shall be wrapped with at least one layer of plastic tape, one-half lapped, extending at least 1-1/2 inches on each side of the field made joints.

Where Amerace 54Super kits are installed, the cable spreaders shall be removed prior to installation of the connector or the spreader shall be held in-place with the cable ID zip tie.

All contractor personnel that will be installing the L-823 connectors shall be trained and certified for installing the L-823 connector by the manufacturer of the L-823 connector. Proposed training course syllabus shall be submitted to the airport for review and approval. Personnel that have been previously trained shall provide documentation to the airport to verify that they have been previously within two (2) years prior to the start of construction. Training and certification cost shall be incidental to the cost of the L-823 connector installation.

The L-823 connectors shall meet Buy American requirements or be included in BA calculation for larger component.

d. Taped or heat-shrink splices. Not Used.

e. Assembly. Surfaces of equipment or conductors being terminated or connected shall be prepared in accordance with industry standard practice and manufacturer's recommendations. All surfaces to be connected shall be thoroughly cleaned to remove all dirt, grease, oxides, nonconductive films, or other foreign material. Paints and other nonconductive coatings shall be removed to expose base metal. Clean all surfaces at least 1/4 inch (6.4 mm) beyond all sides of the larger bonded area on all

mating surfaces. Use a joint compound suitable for the materials used in the connection. Repair painted/coated surface to original condition after completing the connection.

108-3.6 BARE COUNTERPOISE WIRE INSTALLATION FOR LIGHTNING

PROTECTION AND GROUNDING. If shown on the plans or included in the job specifications, bare solid # 6 and bare # 1/0 stranded copper counterpoise wire shall be installed for lightning protection of the underground cables. The method of lightning protection for the airfield lighting circuits shall be:

a. Equipotential. The equipotential method is applicable to all airfield lighting systems; i.e. runway, taxiway, apron – touchdown zone, centerline, edge, threshold and approach lighting systems. The equipotential method is also successfully applied to provide lightning protection for power, signal and communication systems. The light bases, counterpoise, etc – all components - are bonded together and bonded to the vault power system ground loop/electrode.

Counterpoise wire shall be installed in the same trench for the entire length of buried cable, conduits and duct banks that are installed to contain airfield cables. The counterpoise is centered over the cable/conduit/duct to be protected.

The counterpoise conductor shall be installed no less than 8 inches (200 mm) minimum or 12 inches (300 mm) maximum above the raceway or cable to be protected, except as permitted below:

1. The minimum counterpoise conductor height above the raceway or cable to be protected shall be permitted to be adjusted subject to coordination with the airfield lighting and pavement designs.

2. The counterpoise conductor height above the protected raceway(s) or cable(s) shall be calculated to ensure that the raceway or cable is within a 45-degree area of protection, (45 degrees on each side of vertical creating a 90 degree angle).

The counterpoise conductor shall be bonded to each metallic light base, mounting stake, and metallic airfield lighting component.

All metallic airfield lighting components in the field circuit on the output side of the constant current regulator (CCR) or other power source shall be bonded to the airfield lighting counterpoise system.

All components rise and fall at the same potential; with no potential difference, no damaging arcing and no damaging current flow.

See AC 150/5340-30, Design and Installation Details for Airport Visual Aids and NFPA 780, Standard for the Installation of Lightning Protection Systems, Chapter 11, for a detailed description of the Equipotential Method of lightning protection.

Reference FAA STD-019E, Lightning and Surge Protection, Grounding Bonding and Shielding Requirements for Facilities and Electronic Equipment, Part 4.1.1.7.

b. Common Installation requirements. When a metallic light base is used, the grounding electrode shall be bonded to the metallic light base or mounting stake with a No. 6 AWG bare, annealed or soft drawn, solid copper conductor.

When a nonmetallic light base is used, the grounding electrode shall be bonded to the metallic light fixture or metallic base plate with a No. 6 AWG bare, annealed or soft drawn, solid copper conductor.

Grounding electrodes may be rods, ground dissipation plates, radials, or other electrodes listed in the NFPA 70 (NEC) or NFPA 780.

Where raceway is installed by the directional bore, jack and bore, or other drilling method, the counterpoise conductor shall be permitted to be installed concurrently with the directional bore, jack and bore, or other drilling method raceway, external to the raceway or sleeve.

The counterpoise wire shall also be exothermically welded to ground rods installed as shown on the plans but not more than 500 feet (150 m) apart around the entire circuit. The counterpoise system shall be continuous and terminate at the transformer vault or at the power source. It shall be securely attached to the vault or equipment external ground ring or other made electrode-grounding system. The connections shall be made as shown on the plans and in the specifications.

Where an existing airfield lighting system is being extended or modified, the new counterpoise conductors shall be interconnected to existing counterpoise conductors at each intersection of the new and existing airfield lighting counterpoise systems.

c. Parallel Voltage Systems. Provide grounding and bonding in accordance with NFPA 70, National Electrical Code.

108-3.7 COUNTERPOISE INSTALLATION ABOVE MULTIPLE CONDUITS AND DUCT BANKS. Counterpoise wires shall be installed above multiple conduits/duct banks for airfield lighting cables, with the intent being to provide a complete area of protection over the airfield lighting cables. When multiple conduits and/or duct banks for airfield cable are installed in the same trench, the number and location of counterpoise wires above the conduits shall be adequate to provide a complete area of protection measured 45 degrees each side of vertical.

Where duct banks pass under pavement to be constructed in the project, the counterpoise shall be placed above the duct bank. Reference details on the construction plans.

108-3.8 COUNTERPOISE INSTALLATION AT EXISTING DUCT BANKS. When airfield lighting cables are indicated on the plans to be routed through existing duct banks, the new counterpoise wiring shall be terminated at ground rods at each end of the existing duct bank where the cables being protected enter and exit the duct bank. The new counterpoise conductor shall be bonded to the existing counterpoise system.

108-3.9 EXOTHERMIC BONDING. Bonding of counterpoise wire shall be by the exothermic welding process or equivalent method accepted by the RPR. Only personnel experienced in and regularly engaged in this type of work shall make these connections.

Contractor shall demonstrate to the satisfaction of the RPR, the welding kits, materials and procedures to be used for welded connections prior to any installations in the field. The installations shall comply with the manufacturer's recommendations and the following:

a. All slag shall be removed from welds.

b. Using an exothermic weld to bond the counterpoise to a lug on a galvanized light base is not recommended unless the base has been specially modified. Consult the manufacturer's installation directions for proper methods of bonding copper wire to the light base. See AC 150/5340-30 for galvanized light base exception.

c. If called for in the plans, all buried copper and weld material at weld connections shall be thoroughly coated with 6 mm of $3M^{TM}$ ScotchkoteTM, or approved equivalent, or coated with coal tar Bitumastic® material to prevent surface exposure to corrosive soil or moisture.

108-3.10 TESTING. The Contractor shall furnish all necessary equipment and appliances for testing the airport electrical systems and underground cable circuits before and after installation. The Contractor shall perform all tests in the presence of the RPR. The Contractor shall demonstrate the electrical characteristics to the satisfaction of the RPR. All costs for testing are incidental to the respective item being tested. For phased projects, the tests must be completed by phase. The Contractor must maintain the test results throughout the entire project as well as during the warranty period that meet the following:

a. Earth resistance testing methods shall be submitted to the RPR for approval. Earth resistance testing results shall be recorded on an approved form and testing shall be performed in the presence of the RPR. All such testing shall be at the sole expense of the Contractor.

b. Should the counterpoise or ground grid conductors be damaged or suspected of being damaged by construction activities the Contractor shall test the conductors for continuity with a low resistance ohmmeter. The conductors shall be isolated such that no parallel path exists and tested for continuity. The RPR shall approve of the test method selected. All such testing shall be at the sole expense of the Contractor.

After installation, the Contractor shall test and demonstrate to the satisfaction of the RPR the following:

c. That all affected lighting power and control circuits (existing and new) are continuous and free from short circuits.

d. That all affected circuits (existing and new) are free from unspecified grounds.

e. That the insulation resistance to ground of all new non-grounded high voltage series circuits or cable segments is not less than 200 megohms. Verify continuity of all series airfield lighting circuits prior to energization.

f. That the insulation resistance to ground of all new non-grounded conductors of new multiple circuits or circuit segments is not less than 100 megohms.

g. That all affected circuits (existing and new) are properly connected per applicable wiring diagrams.

h. That all affected circuits (existing and new) are operable. Tests shall be conducted that include operating each control not less than 10 times and the continuous operation of each lighting and power circuit for not less than 1/2 hour.

i. That the impedance to ground of each ground rod does not exceed 10 ohms prior to establishing connections to other ground electrodes. The fall-of-potential ground impedance test shall be used, as described by American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE) Standard 81, to verify this requirement. As an alternate, clamp-on style ground impedance test meters may be used to satisfy the impedance testing requirement. Test equipment and its calibration sheets shall be submitted for review and approval by the RPR prior to performing the testing.

Two copies of tabulated results of all cable tests performed shall be supplied by the Contractor to the RPR. Where connecting new cable to existing cable, insulation resistance tests shall be performed on the

new cable prior to connection to the existing circuit.

There are no approved "repair" procedures for items that have failed testing other than complete replacement.

METHOD OF MEASUREMENT

108-4.1 Cable wire installed in ductbank or conduit shall be measured by the number of linear feet installed and grounding connectors accepted as satisfactory. Separate measurement shall be made for each cable or counterpoise wire installed in trench, duct bank or conduit. The measurement for this item shall include additional quantities required for slack.

108-4.2 Splice connections shall be incidental to the project with no separate payment.

108-4.3 Counterpoise, bare copper wire, or other ground wire shall be incidental to the project with no separate payment.

108-4.4 No separate payment will be made for ground rods.

BASIS OF PAYMENT

108-5.1 Payment will be made at the contract unit price for trenching, cable and bare counterpoise wire installed in trench (direct-buried), or cable and equipment ground installed in duct bank or conduit, in place by the Contractor and accepted by the RPR. This price shall be full compensation for furnishing all materials and for all preparation and installation of these materials, and for all labor, equipment, tools, and incidentals, including ground rods and ground connectors and trench marking tape, necessary to complete this item.

Payment will be made under:

Item L-108-1	1-1/C No.8 AWG, 5kV, L-824C Cable	.Per Linear Foot
Item L-108-2	1-1/C No.6 AWG, 600V Ground Wire	.Per Linear Foot

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Advisory Circulars (AC)

AC 150/5340-26	Maintenance of Airport Visual Aid Facilities
AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
AC 150/5345-26	Specification for L-823 Plug and Receptacle, Cable Connectors
AC 150/5345-53	Airport Lighting Equipment Certification Program
Commercial Item Description	
A-A-59544A	Cable and Wire, Electrical (Power, Fixed Installation)
A-A-55809	Insulation Tape, Electrical, Pressure-Sensitive Adhesive, Plastic

ASTM International (ASTM)

	ASTM B3	Standard Specification for Soft or Annealed Copper Wire
	ASTM B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
	ASTM B33	Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes
	ASTM D4388	Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes
Mil Spec		
	MIL-PRF-23586F	Performance Specification: Sealing Compound (with Accelerator), Silicone Rubber, Electrical
	MIL-I-24391	Insulation Tape, Electrical, Plastic, Pressure Sensitive
National Fire Protection Association (NFPA)		
	NFPA-70	National Electrical Code (NEC)
	NFPA-780	Standard for the Installation of Lightning Protection Systems
American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE)		
	ANSI/IEEE STD 81	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
Federal Aviation Administration Standard		
	FAA STD-019E	Lightning and Surge Protection, Grounding Bonding and Shielding Requirements for Facilities and Electronic Equipment

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ITEM L-110 AIRPORT UNDERGROUND ELECTRICAL DUCT BANKS AND CONDUITS

DESCRIPTION

110-1.1 This item shall consist of underground electrical conduits and duct banks (single or multiple conduits encased in concrete or buried in sand) installed per this specification at the locations and per the dimensions, designs, and details shown on the plans. This item shall include furnishing and installing of all underground electrical duct banks and individual and multiple underground conduits. It shall also include all turfing trenching, backfilling, removal, and restoration of any paved or turfed areas; concrete encasement, mandrelling, pulling lines, duct markers, plugging of conduits, and the testing of the installation as a completed system ready for installation of cables per the plans and specifications. This item shall also include furnishing and installing conduits and all incidentals for providing positive drainage of the system. Verification of existing ducts is incidental to the pay items provided in this specification.

Prior to start of any underground construction, the Contractor is responsible for locating all existing cables, utilities and structures at various crossing points to continue operation. The plans may show the approximate location(s) of the utilities as they are believed to exist, but field investigation, locating equipment and/or hand work shall be utilized to confirm precise locations. Any damage to existing cables, utilities, or structures which are to remain in use shall be promptly repaired by the Contractor to the satisfaction of the RPR, at no additional cost to the Airport.

EQUIPMENT AND MATERIALS

110-2.1 GENERAL.

a. All equipment and materials covered by referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification when requested by the RPR.

b. Manufacturer's certifications shall not relieve the Contractor of the responsibility to provide <u>materials</u> per these specifications and acceptable to the RPR. Materials supplied and/or installed that do not comply with these specifications shall be removed, when directed by the RPR and replaced with materials, that comply with these specifications, at the Contractor's cost.

c. All materials and equipment used to construct this item shall be submitted to the RPR for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Submittal data shall be presented in a clear, precise and thorough manner. Original catalog sheets are preferred. Photocopies are acceptable provided they are as good a quality as the original. Clearly and boldly mark each copy to identify products or models applicable to this project. Indicate all optional equipment and delete non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment for which they apply on each submittal sheet. Markings shall be made bold and clear with arrows or circles (highlighting is not acceptable). The Contractor is solely responsible for delays in project that accrue directly or indirectly from late submissions or resubmissions of submittals.

d. The data submitted shall be sufficient, in the opinion of the RPR, to determine compliance with the plans and specifications. The Contractor's submittals shall be electronically submitted in pdf format,

tabbed by specification section. The RPR reserves the right to reject any and all equipment, materials or procedures that do not meet the system design and the standards and codes specified in this document.

e. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of at least twelve (12) months from final acceptance by the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner.

110-2.2 STEEL CONDUIT. Rigid galvanized steel (RGS) conduit and fittings shall be hot dipped galvanized inside and out and conform to the requirements of Underwriters Laboratories Standards 6, 514B, and 1242. All RGS conduits or RGS elbows installed below grade, in concrete, permanently wet locations or other similar environments shall be painted with a 10-mil thick coat of asphaltum sealer or shall have a factory-bonded polyvinyl chloride (PVC) cover. Any exposed galvanizing or steel shall be coated with 10 mils of asphaltum sealer. When using PVC coated RGS conduit, care shall be exercised not to damage the factory PVC coating. Damaged PVC coating shall be repaired per the manufacturer's written instructions. In lieu of PVC coated RGS, corrosion wrap tape shall be permitted to be used where RGS is in contact with direct earth."

110-2.3 PLASTIC CONDUIT. Plastic conduit and fittings-shall conform to the following requirements:

- UL 514B covers W-C-1094-Conduit fittings all types, classes 1 thru 3 and 6 thru 10.
- UL 514C covers W-C-1094- all types, Class 5 junction box and cover in plastic (PVC).
- UL 651 covers W-C-1094-Rigid PVC Conduit, types I and II, Class 4.
- UL 651A covers W-C-1094-Rigid PVC Conduit and high-density polyethylene (HDPE) Conduit type III and Class 4.

Underwriters Laboratories Standards UL-651 and Article 352 of the current National Electrical Code shall be one of the following, as shown on the plans:

a. Type I–Schedule 40 and Schedule 80 PVC suitable for underground use either direct-buried or encased in concrete.

b. Type II–Schedule 40 PVC suitable for either above ground or underground use.

c. Type III – Schedule 80 PVC suitable for either above ground or underground use either direct-buried or encased in concrete.

d. Type III –HDPE pipe, minimum standard dimensional ratio (SDR) 11, suitable for placement with directional boring under pavement.

The type of solvent cement shall be as recommended by the conduit/fitting manufacturer.

110-2.4 SPLIT CONDUIT. Split conduit shall be pre-manufactured for the intended purpose and shall be made of steel or plastic.

110-2.5 CONDUIT SPACERS. Conduit spacers shall be prefabricated interlocking units manufactured for the intended purpose. They shall be of double wall construction made of high grade, high density polyethylene complete with interlocking cap and base pads. They shall be designed to accept No. 4

reinforcing bars installed vertically.

110-2.6 CONCRETE. Concrete shall be proportioned, placed and cured per Item P-610, Concrete for Miscellaneous Structures.

110-2.7 PRECAST CONCRETE STRUCTURES. Not Used.

110-2.8 FLOWABLE BACKFILL. Flowable material used to back fill conduit and duct bank trenches shall conform to the requirements of Item P-153, Controlled Low Strength Material.

110-2.9 DETECTABLE WARNING TAPE. Plastic, detectable, American Public Works Association (APWA) red (electrical power lines, cables, conduit and lighting cable), orange (telephone/fiber optic cabling) with continuous legend magnetic tape shall be polyethylene film with a metallized foil core and shall be 3-6 inches (75-150 mm) wide. Detectable tape is incidental to the respective bid item.

CONSTRUCTION METHODS

110-3.1 GENERAL. The Contractor shall install underground duct banks and conduits at the approximate locations indicated on the plans. The RPR shall indicate specific locations as the work progresses, if required to differ from the plans. Duct banks and conduits shall be of the size, material, and type indicated on the plans or specifications. Where no size is indicated on the plans or in the specifications, conduits shall be not less than 2 inches (50 mm) inside diameter or comply with the National Electrical Code based on cable to be installed, whichever is larger. All duct bank and conduit lines shall be laid so as to grade toward access points and duct or conduit ends for drainage. Unless shown otherwise on the plans, grades shall be at least 3 inches (75 mm) per 100 feet (30 m). On runs where it is not practicable to maintain the grade all one way, the duct bank and conduit lines shall be graded from the center in both directions toward access points or conduit ends, with a drain into the storm drainage system. Pockets or traps where moisture may accumulate shall be avoided. Under pavement, the top of the duct bank shall not be less than 18 inches (0.5 m) below the subgrade; in other locations, the top of the duct bank or underground conduit shall be be not less than 18 inches (0.5 m) below finished grade.

The Contractor shall mandrel each individual conduit whether the conduit is direct-buried or part of a duct bank. An iron-shod mandrel, not more than 1/4 inch (6 mm) smaller than the bore of the conduit shall be pulled or pushed through each conduit. The mandrel shall have a leather or rubber gasket slightly larger than the conduit hole.

The Contractor shall swab out all conduits/ducts and clean base can, manhole, pull boxes, etc., interiors immediately prior to pulling cable. Once cleaned and swabbed the light bases, manholes, pull boxes, etc., and all accessible points of entry to the duct/conduit system shall be kept closed except when installing cables. Cleaning of ducts, base cans, manholes, etc., is incidental to the pay item of the item being cleaned. All raceway systems left open, after initial cleaning, for any reason shall be recleaned at the Contractor's expense. All accessible points shall be kept closed when not installing cable. The Contractor shall verify existing ducts proposed for use in this project as clear and open. The Contractor shall notify the RPR of any blockage in the existing ducts.

For pulling the permanent wiring, each individual conduit, whether the conduit is direct-buried or part of a duct bank, shall be provided with a 200-pound (90 kg) test polypropylene pull rope. The ends shall be secured and sufficient length shall be left in access points to prevent it from slipping back into the conduit. Where spare conduits are installed, as indicated on the plans, the open ends shall be plugged with removable tapered plugs, designed for this purpose.

All conduits shall be securely fastened in place during construction and shall be plugged to prevent
contaminants from entering the conduits. Any conduit section having a defective joint shall not be installed. Ducts shall be supported and spaced apart using approved spacers at intervals not to exceed 5 feet (1.5 m).

Unless otherwise shown on the plans, concrete encased duct banks shall be used when crossing under pavements expected to carry aircraft loads, such as runways, taxiways, taxilanes, ramps and aprons. When under paved shoulders and other paved areas, conduit and duct banks shall be encased using flowable fill for protection.

All conduits within concrete encasement of the duct banks shall terminate with female ends for ease in current and future use. Install factory plugs in all unused ends. Do not cover the ends or plugs with concrete.

Where turf is well established and the sod can be removed, it shall be carefully stripped and properly stored.

Trenches for conduits and duct banks may be excavated manually or with mechanical trenching equipment unless in pavement, in which case they shall be excavated with mechanical trenching equipment. Walls of trenches shall be essentially vertical so that a minimum of shoulder surface is disturbed. Blades of graders shall not be used to excavate the trench.

When rock is encountered, the rock shall be removed to a depth of at least 3 inches (75 mm) below the required conduit or duct bank depth and it shall be replaced with bedding material of earth or sand containing no mineral aggregate particles that would be retained on a 1/4-inch (6.3 mm) sieve. Flowable backfill may alternatively be used

Underground electrical warning (Caution) tape shall be installed in the trench above all underground duct banks and conduits in unpaved areas. Contractor shall submit a sample of the proposed warning tape for approval by the RPR. If not shown on the plans, the warning tape shall be located 6 inches above the duct/conduit or the counterpoise wire if present.

Joints in plastic conduit shall be prepared per the manufacturer's recommendations for the particular type of conduit. Plastic conduit shall be prepared by application of a plastic cleaner and brushing a plastic solvent on the outside of the conduit ends and on the inside of the couplings. The conduit fitting shall then be slipped together with a quick one-quarter turn twist to set the joint tightly. Where more than one conduit is placed in a single trench, or in duct banks, joints in the conduit shall be staggered a minimum of 2 feet (60 cm).

Changes in direction of runs exceeding 10 degrees, either vertical or horizontal, shall be accomplished using manufactured sweep bends.

Whether or not specifically indicated on the drawings, where the soil encountered at established duct bank grade is an unsuitable material, as determined by the RPR, the unsuitable material shall be removed per Item P-152 and replaced with suitable material. Additional duct bank supports shall be installed, as approved by the RPR.

All excavation shall be unclassified and shall be considered incidental to Item L-110. Dewatering necessary for duct installation, and erosion per federal, state, and local requirements is incidental to Item L-110.

Unless otherwise specified, excavated materials that are deemed by the RPR to be unsuitable for use in backfill or embankments shall be removed and disposed of offsite.

Any excess excavation shall be filled with suitable material approved by the RPR and compacted per Item P-152.

It is the Contractor's responsibility to locate existing utilities within the work area prior to excavation. Where

existing active cables) cross proposed installations, the Contractor shall ensure that these cables are adequately protected. Where crossings are unavoidable, no splices will be allowed in the existing cables, except as specified on the plans. Installation of new cable where such crossings must occur shall proceed as follows:

a. Existing cables shall be located manually. Unearthed cables shall be inspected to assure absolutely no damage has occurred

b. Trenching, etc., in cable areas shall then proceed with approval of the RPR, with care taken to minimize possible damage or disruption of existing cable, including careful backfilling in area of cable.

In the event that any previously identified cable is damaged during the course of construction, the Contractor shall be responsible for the complete repair.

110-3.2 DUCT BANKS. Unless otherwise shown in the plans, duct banks shall be installed so that the top of the concrete envelope is not less than 18 inches (0.5 m) below the bottom of the base or stabilized base course layers where installed under runways, taxiways, aprons, or other paved areas, and not less than 18 inches (0.5 m) below finished grade where installed in unpaved areas.

Unless otherwise shown on the plans, duct banks under paved areas shall extend at least 3 feet (1 m) beyond the edges of the pavement or 3 feet (1 m) beyond any under drains that may be installed alongside the paved area. Trenches for duct banks shall be opened the complete length before concrete is placed so that if any obstructions are encountered, provisions can be made to avoid them. Unless otherwise shown on the plans, all duct banks shall be placed on a layer of concrete not less than 3 inches (75 mm) thick prior to its initial set. The Contractor shall space the conduits not less than 3 inches (75 mm) apart (measured from outside wall to outside wall). All such multiple conduits shall be placed around and on top of the conduits not less than 3 inches (75 mm) thick prior to its not less than 3 inches (75 mm) thick prior to its not less than 3 inches (75 mm) the conduits not less than 3 inches (75 mm) apart (measured from outside wall to outside wall). All such multiple conduits shall be placed around and on top of the conduits not less than 3 inches (75 mm) thick unless otherwise shown on the plans. All conduits shall terminate with female ends for ease of access in current and future use. Install factory plugs in all unused ends. Do not cover the ends or plugs with concrete.

Conduits forming the duct bank shall be installed using conduit spacers. No. 4 reinforcing bars shall be driven vertically into the soil a minimum of 6 inches (150 mm) to anchor the assembly into the earth prior to placing the concrete encasement. For this purpose, the spacers shall be fastened down with locking collars attached to the vertical bars. Spacers shall be installed at 5-foot (1.5-m) intervals. Spacers shall be in the proper sizes and configurations to fit the conduits. Locking collars and spacers shall be submitted to the RPR for review prior to use.

When specified, the Contractor shall reinforce the bottom side and top of encasements with steel reinforcing mesh or fabric or other approved metal reinforcement. When directed, the Contractor shall supply additional supports where the ground is soft and boggy, where ducts cross under roadways, or where shown on the plans. Under such conditions, the complete duct structure shall be supported on reinforced concrete footings, piers, or piles located at approximately 5-foot (1.5-m) intervals.

All pavement surfaces that are to have ducts installed therein shall be neatly saw cut to form a vertical face. All excavation shall be included in the contract with price for the duct.

Install a plastic, detectable, color as noted, 3 to 6 inches (75 to 150 mm) wide tape, 8 inches (200 mm) minimum below grade above all underground conduit or duct lines not installed under pavement. Utilize the 3-inch (75-mm) wide tape only for single conduit runs. Utilize the 6-inch (150-mm) wide tape for multiple conduits and duct banks. For duct banks equal to or greater than 24 inches (600 mm) in width, utilize more than one tape for sufficient coverage and identification of the duct bank as required.

When existing cables are to be placed in split duct, encased in concrete, the cable shall be carefully located and exposed by hand tools. Prior to being placed in duct, the RPR shall be notified so that he may inspect the cable and determine that it is in good condition. Where required, split duct shall be installed as shown on the drawings or as required by the RPR.

110-3.3 CONDUITS WITHOUT CONCRETE ENCASEMENT. All conduits shall be concrete encased. This section does not apply.

110-3.4 MARKERS. The location of each end and of each change of direction of conduits and duct banks shall be marked by a concrete slab marker 2 feet (60 cm) square and 4 - 6 inches (100 - 150 mm) thick extending approximately one inch (25 mm) above the surface. The markers shall also be located directly above the ends of all conduits or duct banks, except where they terminate in a junction/access structure or building. Each cable or duct run from a line of lights and signs to the equipment vault must be marked at approximately every 200 feet (61 m) along the cable or duct run, with an additional marker at each change of direction of cable or duct run.

The Contractor shall impress the word "DUCT" or "CONDUIT" on each marker slab. Impression of letters shall be done in a manner, approved by the RPR, for a neat, professional appearance. All letters and words must be neatly stenciled. After placement, all markers shall be given one coat of high-visibility orange paint, as approved by the RPR. The Contractor shall also impress on the slab the number and size of conduits beneath the marker along with all other necessary information as determined by the RPR. The letters shall be 4 inches (100 mm) high and 3 inches (75 mm) wide with width of stroke 1/2 inch (12 mm) and 1/4 inch (6 mm) deep or as large as the available space permits. Furnishing and installation of duct markers is incidental to the respective duct pay item. Contractor shall submit a shop drawing detailing the location and words of each ductbank marker.

110-3.5 BACKFILLING FOR CONDUITS. For conduits, 8 inches (200 mm) of sand, soft earth, or other fine fill (loose measurement) shall be placed around the conduits ducts and carefully tamped around and over them with hand tampers. The remaining trench shall then be backfilled and compacted per Item P-152 except that material used for back fill shall be select material not larger than 4 inches (100 mm) in diameter.

Flowable backfill may alternatively be used.

Trenches shall not contain pools of water during back filling operations.

The trench shall be completely backfilled and tamped level with the adjacent surface; except that, where rock is to be placed over the trench, the backfilling shall be stopped at a depth equal to the thickness of the rock to be used, with proper allowance for settlement.

Any excess excavated material shall be removed and disposed of per instructions issued by the RPR.

110-3.6 BACKFILLING FOR DUCT BANKS. After the concrete has cured, the remaining trench shall be backfilled and compacted per Item P-152 "Excavation and Embankment" except that the material used for backfill shall be select material not larger than 4 inches (100 mm) in diameter. In addition to the requirements of Item P-152, where duct banks are installed under pavement, one moisture/density test per lift shall be made for each 250 linear feet (76 m) of duct bank or one work period's construction, whichever is less.

Flowable backfill may alternatively be used.

Trenches shall not contain pools of water during backfilling operations.

The trench shall be completely backfilled and tamped level with the adjacent surface; except that, where sod is to be placed over the trench, the backfilling shall be stopped at a depth equal to the thickness of the sod to be used, with proper allowance for settlement.

Any excess excavated material shall be removed and disposed of per instructions issued by the RPR.

110-3.7 RESTORATION. Where sod has been removed, it shall be replaced as soon as possible after the backfilling is completed. All areas disturbed by the work shall be restored to its original condition. The restoration shall include rock installation as shown on the plans. The Contractor shall be held responsible for maintaining all disturbed surfaces and replacements until final acceptance. All restoration shall be considered incidental to the respective L-110 pay item. Following restoration of all trenching near airport movement surfaces, the Contractor shall thoroughly visually inspect the area for foreign object debris (FOD), and remove any such FOD that is found. This FOD inspection and removal shall be considered incidental to the pay item of which it is a component part.

110-3.8 OWNERSHIP OF REMOVED CABLE. All removed cable shall become property of the contractor and shall be removed off site.

METHOD OF MEASUREMENT

110-4.1 Underground conduits and duct banks shall be measured by the linear feet of conduits and duct banks installed, including encasement, locator tape, trenching and backfill with designated material, and restoration, rebar, concrete, counterpoise, grounding, ground rod, testing of grounding, restoration, and for drain lines, the termination at the drainage structure, all measured in place, completed, and accepted. Separate measurement shall be made for the various types and sizes.

BASIS OF PAYMENT

110-5.1 Payment will be made at the contract unit price per linear foot for each type and size of conduit and duct bank completed and accepted, including trench and backfill with the designated material, and, for drain lines, the termination at the drainage structure. This price shall be full compensation for removal and disposal of existing duct banks and conduits as shown on the plans, furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete this item per the provisions and intent of the plans and specifications. Note, Payment for airfield lighting (AFL) ductbank or FAA ductbank (2W-3", 2W-4", 4W-3", 4W-4", 6W-4", 6W-2") shall be the same regardless if ductbank is installed in non-paved earth, new or existing asphalt, or concrete and there shall be no separate payment for the various pavement or earth restoration required for each type of ductbank. Payment for 1W-2" conduit shall be different for the various pavement location that the single conduit is installed in.

Payment will be made under:

Item L-110-1	2W-3" FAA Ductbank	Per Linear Foot
Item L-110-2	2W-4" FAA Ductbank	.Per Linear Foot
Item L-110-3	4W-3" FAA Ductbank	.Per Linear Foot
Item L-110-4	4W-4" FAA Ductbank	Per Linear Foot
Item L-110-5	1W-2" AFL Concrete Encased Electrical Conduit in	
	New PCC	.Per Linear Foot

Item L-110-6	1W-2" AFL Concrete Encased Electrical Conduit in	
	New Asphalt Shoulder	Per Linear Foot
Item L-110-7	1W-2" AFL Concrete Encased Electrical Conduit in	
	Non Paved Earth	Per Linear Foot
Item L-110-8	4W-4" AFL Ductbank	Per Linear Foot
Item L-110-9	6W-4" AFL Ductbank	Per Linear Foot
Item L-110-10	2W-4" AFL Ductbank	Per Linear Foot
Item L-110-11	6W-2" FAA Ductbank	Per Linear Foot

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Advisory Circular (AC)	
AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-53	Airport Lighting Equipment Certification Program
ASTM International (ASTM)	
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

National Fire Protection Association (NFPA)

NFPA-70 National Electrical Code (NEC)

Underwriters Laboratories (UL)

UL Standard 6	Electrical Rigid Metal Conduit - Steel
UL Standard 514B	Conduit, Tubing, and Cable Fittings
UL Standard 514C	Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL Standard 1242	Electrical Intermediate Metal Conduit Steel
UL Standard 651	Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL Standard 651A	Type EB and A Rigid PVC Conduit and HDPE Conduit

END OF ITEM L-110

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ITEM L-115 ELECTRICAL MANHOLES, HANDHOLES, AND JUNCTION STRUCTURES

DESCRIPTION

115-1.1 This item shall consist of electrical manholes and junction structures (hand holes, pull boxes, junction cans, etc.) installed per this specification, at the indicated locations and conforming to the lines, grades and dimensions shown on the plans or as required by the RPR. This item shall include the installation of each electrical manhole and/or junction structures with all associated excavation, backfilling, sheeting and bracing, concrete, reinforcing steel, ladders, appurtenances, testing, dewatering and restoration of surfaces to the satisfaction of the RPR. This specification covers airfield lighting and FAA MALSR structures.

EQUIPMENT AND MATERIALS

115-2.1 GENERAL.

a. All equipment and materials covered by referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification when so requested by the RPR.

b. Manufacturer's certifications shall not relieve the Contractor of the responsibility to provide materials per these specifications. Materials supplied and/or installed that do not comply with these specifications shall be removed (when directed by the RPR) and replaced with materials that comply with these specifications at the Contractor's cost.

c. All materials and equipment used to construct this item shall be submitted to the RPR for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Submittal data shall be presented in a clear, precise and thorough manner. Original catalog sheets are preferred. Photocopies are acceptable provided they are as good a quality as the original. Clearly and boldly mark each copy to identify products or models applicable to this project. Indicate all optional equipment and delete any non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment to which they apply on each submittal sheet. Markings shall be made bold and clear with arrows or circles (highlighting is not acceptable). The Contractor is solely responsible for delays in the project that may accrue directly or indirectly from late submissions or resubmissions of submittals.

d. The data submitted shall be sufficient, in the opinion of the RPR, to determine compliance with the plans and specifications. The Contractor's submittals shall be electronically submitted in pdf format, tabbed by specification section. The RPR reserves the right to reject any and all equipment, materials or procedures that do not meet the system design and the standards and codes, specified in this document.

e. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of at least twelve (12) months

from the date of final acceptance by the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner.

115-2.2 CONCRETE STRUCTURES. Concrete shall be proportioned, placed, and cured per Item P-610, Concrete for Miscellaneous Structures. Cast-in-place concrete structures shall be as shown on the plans.

115-2.3 PRECAST CONCRETE STRUCTURES. Precast concrete structures shall be furnished by a plant meeting National Precast Concrete Association Plant Certification Program or another engineer approved third party certification program. Provide precast concrete structures where shown on the plans.

Precast concrete structures shall be an approved standard design of the manufacturer. Precast units shall have mortar or bitumastic sealer placed between all joints to make them watertight. The structure shall be designed to withstand 100,000 lb aircraft loads, unless otherwise shown on the plans. Openings or knockouts shall be provided in the structure as detailed on the plans.

Threaded inserts and pulling eyes shall be cast in as shown on the plans.

If the Contractor chooses to propose a different structural design, signed and sealed shop drawings, design calculations, and other information requested by the RPR shall be submitted by the Contractor to allow for a full evaluation by the RPR. The RPR shall review per the process defined in the General Provisions.

115-2.4 JUNCTION BOXES. Junction boxes shall be L-867 Class 1 (non-load bearing) or L-868 Class 1 (load bearing) airport light bases that are encased in concrete. The light bases shall have a L-894 blank cover, gasket, and stainless steel hardware. All bolts, studs, nuts, lock washers, and other similar fasteners used for the light fixture assemblies must be fabricated from 316L (equivalent to EN 1.4404), 18-8, 410, or 416 stainless steel. If 18-8, 410, or 416 stainless steel is utilized it shall be passivated and be free from any discoloration. Covers shall be 3/8-inch (9-mm) thickness for L-867 and 3/4-inch (19-mm) thickness for L-868. All junction boxes shall be provided with both internal and external ground lugs.

115-2.5 MORTAR. The mortar shall be composed of one part of cement and two parts of mortar sand, by volume. The cement shall be per the requirements in ASTM C150, Type I. The sand shall be per the requirements in ASTM C144. Hydrated lime may be added to the mixture of sand and cement in an amount not to exceed 15% of the weight of cement used. The hydrated lime shall meet the requirements of ASTM C206. Water shall be potable, reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product.

115-2.6 CONCRETE. All concrete used in structures shall conform to the requirements of Item P-610, Concrete for Miscellaneous Structures.

115-2.7 FRAMES AND COVERS. The frames shall conform to one of the following requirements:

a.	ASTM A48	Gray iron castings
b.	ASTM A47	Malleable iron castings
c.	ASTM A27	Steel castings
d.	ASTM A283, Grade D	Structural steel for grates and frames

e.	ASTM A536	Ductile iron castings
f.	ASTM A897	Austempered ductile iron cast

ASTM A897 Austempered ductile iron castings

All castings specified shall withstand a maximum tire pressure of 250 psi and maximum load of 100,000 lbs.

All castings or structural steel units shall conform to the dimensions shown on the plans and shall be designed to support the loadings specified.

Each frame and cover unit shall be provided with fastening members to prevent it from being dislodged by traffic, but which will allow easy removal for access to the structure.

All castings shall be thoroughly cleaned. After fabrication, structural steel units shall be galvanized to meet the requirements of ASTM A123.

Each cover shall be equipped with a spring assist to allow maintenance to easily open covers without lifting equipment.

Each cover shall have the word "ELECTRIC" or other approved designation cast on it. Each frame and cover shall be as shown on the plans or approved equivalent. No cable notches are required.

Each manhole shall be provided with a "DANGER -- PERMIT-REQUIRED CONFINED SPACE, DO NOT ENTER" safety warning sign as detailed in the Contract Documents and in accordance with OSHA 1910.146 (c)(2).

115-2.8 LADDERS. Ladders, if specified, shall be galvanized steel or as shown on the plans.

115-2.9 **REINFORCING STEEL.** All reinforcing steel shall be deformed bars of new billet steel meeting the requirements of ASTM A615, Grade 60.

115-2.10 **BEDDING/SPECIAL BACKFILL.** Bedding or special backfill shall be as shown on the plans.

115-2.11 FLOWABLE BACKFILL. Flowable material used to backfill shall conform to the requirements of Item P-153, Controlled Low Strength Material.

SADDLE RACKS. Saddle racks shall be of plastic or fiberglass material with 115-2.12 stainless steel anchors.

PLASTIC CONDUIT. Plastic conduit shall comply with Item L-110, Airport 115-2.13 Underground Electrical Duct Banks and Conduits.

115-2.14 **CONDUIT TERMINATORS.** Conduit terminators shall be pre-manufactured for the specific purpose and sized as required or as shown on the plans.

115-2.15 PULLING-IN IRONS. Pulling-in irons shall be manufactured with 7/8-inch (22 mm) diameter hot-dipped galvanized steel or stress-relieved carbon steel roping designed for concrete applications (7 strand, 1/2-inch (12 mm) diameter with an ultimate strength of 270,000 psi (1862 MPa)). Where stress-relieved carbon steel roping is used, a rustproof sleeve shall be installed at the hooking point and all exposed surfaces shall be encapsulated with a polyester coating to prevent corrosion.

115-2.16 GROUND RODS. Ground rods shall be one piece, copper clad steel. The ground rods shall be of the length and diameter specified on the plans, but in no case shall they be less than 10 feet long nor less than 3/4 inch in diameter. Ground rods shall be installed outside the structure at location detailed by RPR.

CONSTRUCTION METHODS

115-3.1 UNCLASSIFIED EXCAVATION. It is the Contractor's responsibility to locate existing utilities within the work area prior to excavation. Damage to utility lines, through lack of care in excavating, shall be repaired or replaced to the satisfaction of the RPR without additional expense to the Owner.

The Contractor shall perform excavation for structures and structure footings to the lines and grades or elevations shown on the plans or as staked by the RPR. The excavation shall be of sufficient size to permit the placing of the full width and length of the structure or structure footings shown.

All excavation shall be unclassified and shall be considered incidental to Item L-115. Dewatering necessary for structure installation and erosion per federal, state, and local requirements is incidental to Item L-115.

Boulders, logs and all other objectionable material encountered in excavation shall be removed. All rock and other hard foundation material shall be cleaned of all loose material and cut to a firm surface either level, stepped or serrated, as directed by the RPR. All seams, crevices, disintegrated rock and thin strata shall be removed. When concrete is to rest on a surface other than rock, special care shall be taken not to disturb the bottom of the excavation. Excavation to final grade shall not be made until just before the concrete or reinforcing is to be placed.

The Contractor shall provide all bracing, sheeting and shoring necessary to implement and protect the excavation and the structure as required for safety or conformance to governing laws. The cost of bracing, sheeting and shoring shall be included in the unit price bid for the structure.

Unless otherwise provided, bracing, sheeting and shoring involved in the construction of this item shall be removed by the Contractor after the completion of the structure. Removal shall be effected in a manner that will not disturb or mar finished masonry. The cost of removal shall be included in the unit price bid for the structure.

After each excavation is completed, the Contractor shall notify the RPR. Structures shall be placed after the RPR has approved the depth of the excavation and the suitability of the foundation material.

Prior to installation the Contractor shall provide a minimum of 6 inches (150 mm) of sand or a material approved by the RPR as a suitable base to receive the structure. The base material shall be compacted and graded level and at proper elevation to receive the structure in proper relation to the conduit grade or ground cover requirements, as indicated on the plans.

115-3.2 CONCRETE STRUCTURES. Concrete structures shall be built on prepared foundations conforming to the dimensions and form indicated on the plans. The concrete and construction methods shall conform to the requirements specified in Item P-610. Any reinforcement required shall be placed as indicated on the plans and shall be approved by the RPR before the concrete is placed.

115-3.3 PRECAST UNIT INSTALLATIONS. Precast units shall be installed plumb and true. Joints shall be made watertight by use of sealant at each tongue-and-groove joint and at roof of manhole. Excess sealant shall be removed and severe surface projections on exterior of neck shall be removed.

115-3.4 PLACEMENT AND TREATMENT OF CASTINGS, FRAMES AND

FITTINGS. All castings, frames and fittings shall be placed in the positions indicated on the Plans or as directed by the RPR and shall be set true to line and to correct elevation. If frames or fittings are to be set in concrete or cement mortar, all anchors or bolts shall be in place and position before the concrete or mortar is placed. The unit shall not be disturbed until the mortar or concrete has set.

Field connections shall be made with bolts, unless indicated otherwise. Welding will not be permitted unless shown otherwise on the approved shop drawings and written approval is granted by the casting manufacturer. Erection equipment shall be suitable and safe for the workman. Errors in shop fabrication or deformation resulting from handling and transportation that prevent the proper assembly and fitting of parts shall be reported immediately to the RPR and approval of the method of correction shall be obtained. Approved corrections shall be made at Contractor's expense.

Anchor bolts and anchors shall be properly located and built into connection work. Bolts and anchors shall be preset by the use of templates or such other methods as may be required to locate the anchors and anchor bolts accurately.

Pulling-in irons shall be located opposite all conduit entrances into structures to provide a strong, convenient attachment for pulling-in blocks when installing cables. Pulling-in irons shall be set directly into the concrete walls of the structure.

115-3.5 INSTALLATION OF LADDERS. Ladders shall be installed such that they may be removed if necessary. Mounting brackets shall be supplied top and bottom and shall be cast in place during fabrication of the structure or drilled and grouted in place after erection of the structure.

115-3.6 REMOVAL OF SHEETING AND BRACING. In general, all sheeting and bracing used to support the sides of trenches or other open excavations shall be withdrawn as the trenches or other open excavations are being refilled. That portion of the sheeting extending below the top of a structure shall be withdrawn, unless otherwise directed, before more than 6 inches (150 mm) of material is placed above the top of the structure and before any bracing is removed. Voids left by the sheeting shall be carefully refilled with selected material and rammed tight with tools especially adapted for the purpose or otherwise as may be approved.

The RPR may direct the Contractor to delay the removal of sheeting and bracing if, in his judgment, the installed work has not attained the necessary strength to permit placing of backfill.

115-3.7 BACKFILLING. After a structure has been completed, the area around it shall be backfilled in horizontal layers not to exceed 6 inches (150 mm) in thickness measured after compaction to the density requirements in Item P-152. Each layer shall be deposited all around the structure to approximately the same elevation. The top of the fill shall meet the elevation shown on the plans or as directed by the RPR.

Backfill shall not be placed against any structure until approval is given by the RPR. In the case of concrete, such approval shall not be given until tests made by the laboratory under supervision of the RPR establish that the concrete has attained sufficient strength to provide a factor of safety against

damage or strain in withstanding any pressure created by the backfill or the methods used in placing it.

Where required, the RPR may direct the Contractor to add, at his own expense, sufficient water during compaction to assure a complete consolidation of the backfill. The Contractor shall be responsible for all damage or injury done to conduits, duct banks, structures, property or persons due to improper placing or compacting of backfill.

115-3.8 CONNECTION OF DUCT BANKS. To relieve stress of joint between concreteencased duct banks and structure walls, reinforcement rods shall be placed in the structure wall and shall be formed and tied into duct bank reinforcement at the time the duct bank is installed.

115-3.9 GROUNDING.

- A. Structures for Airfield Lighting Cable. A ground rod shall be installed in the floor of all concrete structures so that the top of rod extends 6 inches (150 mm) above the floor. The ground rod shall be installed within one foot (30 cm) of a corner of the concrete structure. Ground rods shall be installed prior to casting the bottom slab. Where the soil condition does not permit driving the ground rod into the earth without damage to the ground rod, the Contractor shall drill a 4-inch (100 mm) diameter hole into the earth to receive the ground rod. The hole around the ground rod shall be filled throughout its length, below slab, with Portland cement grout. Ground rods shall be installed in precast bottom slab of structures by drilling a hole through bottom slab and installing the ground rod. Bottom slab penetration shall be sealed watertight with Portland cement grout around the ground rod.
- **B.** Structures for MALSR System. A ground rod shall be installed outside of the structure and shall be installed within 2' of the structure at location detailed by RPR. Contractor shall drill a hole in the side of the handhole and shall route 4/0 bare stranded copper to the grounding bus inside the structure.
- C. Grounding Bus. A grounding bus of 4/0 bare stranded copper shall be exothermically bonded to the ground rod and loop the concrete structure walls. The ground bus shall be a minimum of one foot (30 cm) above the floor of the structure and separate from other cables. No. 2 American wire gauge (AWG) bare copper pigtails shall bond the grounding bus to all cable trays and other metal hardware within the concrete structure. Connections to the grounding bus shall be exothermic. If an exothermic weld is not possible, connections to the grounding bus shall be made by using connectors approved for direct burial in soil or concrete per UL 467.
- **D.** CLEANUP AND REPAIR. After erection of all galvanized items, damaged areas shall be repaired by applying a liquid cold-galvanizing compound per MIL-P-21035. Surfaces shall be prepared and compound applied per the manufacturer's recommendations.
- E. Prior to acceptance, the entire structure shall be cleaned of all dirt and debris.
- F. Contractor shall provide as-builts of all structures including location of conduits.
- **G. RESTORATION.** After the backfill is completed, the Contractor shall dispose of all surplus material, dirt and rubbish from the site. The Contractor shall restore all disturbed areas equivalent to or better than their original condition. All sodding, rock installation, grading and restoration shall be considered incidental to the respective Item L-115 pay item.

The Contractor shall grade around structures as required to provide positive drainage away from the structure.

Areas with special surface treatment, such as roads, sidewalks, or other paved areas shall have backfill compacted to match surrounding areas, and surfaces shall be repaired using materials comparable to original materials.

Following restoration of all trenching near airport movement surfaces, the Contractor shall thoroughly visually inspect the area for foreign object debris (FOD), and remove any such FOD that is found. This FOD inspection and removal shall be considered incidental to the pay item of which it is a component part.

After all work is completed, the Contractor shall remove all tools and other equipment, leaving the entire site free, clear and in good condition.

- H. INSPECTION. Prior to final approval, the electrical structures shall be thoroughly inspected for conformance with the plans and this specification. Any indication of defects in materials or workmanship shall be further investigated and corrected. The earth resistance to ground of each ground rod shall not exceed 15 ohms. Each ground rod shall be tested using the fall-of-potential ground impedance test per American National Standards Institute / Institute of Electrical and Electronic Engineers (ANSI/IEEE) Standard 81. This test shall be performed prior to establishing connections to other ground electrodes. Contractor shall record the earth resistance to ground of each ground rod and the location of the ground rod on a drawing for FAA review and approval.
- I. HANDHOLE ELEVATION ADJUSTMENTS. The Contractor shall adjust the tops of existing manholes in areas designated in the Contract Documents to the new elevations shown. The Contractor shall be responsible for determining the exact height adjustment required to raise or lower the top of each manhole to the new elevations. The existing top elevation of each manhole to be adjusted shall be determined in the field and subtracted/added from the proposed top elevation.

The Contractor shall adjust the existing manholes as shown and detail on the plans.

The Contractor shall construct a concrete slab around the top of adjusted structures located in graded areas that are not to be paved. The concrete slab shall conform to the dimensions shown on the plans.

J. DUCT EXTENSION TO EXISTING DUCTS. Where existing concrete encased ducts are to be extended, the duct extension shall be concrete encased plastic conduit. The fittings to connect the ducts together shall be standard manufactured connectors designed and approved for the purpose. The duct extensions shall be installed according to the concrete encased duct detail and as shown on the plans.

METHOD OF MEASUREMENT

ELECTRICAL HANDHOLES AND JUNCTION STRUCTURES. This paragraph details the method of measurement for all electrical handholes and junction structures. Payment for electrical handholes and junction structures shall be measured by each unit completed in place and accepted by the RPR. The following items shall be included in the price of each unit: All required excavation and dewatering: sheeting and bracing; structure, ground rod, saddle racks, ground

wire, testing, all required backfilling with on-site materials; restoration of all surfaces and finished grading and turfing; all required connections; temporary cables and connections; and ground rod testing. This bid item also includes the cost for a structural engineer in the state of Nevada to stamp the structure.

115-4.2 HANDHOLE ELEVATION ADJUSTMENTS. This paragraph details the method of measurement for all handhole elevation adjustments. Payment for manhole elevation adjustments shall be measured by the completed unit installed, in place, completed, and accepted by the RPR. Separate measurement shall not be made for the various types and sizes.

115-4.3 ACCESSING HANDHOLES/MANHOLES/JUNCTION CANS FOR

CIRCUITING. The quantity of handholes or manholes requiring access for circuiting shall be incidental to the project with no separate payment regardless of the number of times it has been accessed. Contractor shall assume that all existing handhole/manholes shown on drawings require access for circuiting. Each Handhole/Manhole will require water removal and confined space permit for manholes. No separate payment will be made for entering an existing manhole/handhole multiple times.

BASIS OF PAYMENT

115-5.1 The accepted quantity of electrical handholes, and junction structures will be paid for at the Contract unit price per each, complete and in place. This price shall be full compensation for furnishing all materials and for all preparation, excavation, backfilling and placing of the materials, furnishing and installation of appurtenances and connections to duct banks and other structures as may be required to complete the item as shown on the plans and for all labor, equipment, tools and incidentals necessary to complete the structure.

115-5.2 Payment shall be made at the contract unit price for handhole elevation adjustments. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary, including but not limited to, spacers, concrete, rebar, dewatering, excavating, backfill, topsoil, sodding and pavement restoration, where required, to complete this item as shown in the plans and to the satisfaction of the RPR.

Payment will be made under:

Item L-115-1	4' by 4' by 4' Electrical Handhole – Aircraft Rated	.Per Each
Item L-115-2	Existing Electrical Handhole/Junction Structure Elevation	
	Adjustment – Aircraft Rated	.Per Each

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

American National Standards Institute / Insulated Cable Engineers Association (ANSI/ICEA)

ANSI/IEEE STD 81 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

Advisory Circular (AC)	
AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
AC 150/5345-26	Specification for L-823 Plug and Receptacle, Cable Connectors
AC 150/5345-42	Specification for Airport Light Bases, Transformer Housings, Junction Boxes, and Accessories
AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-53	Airport Lighting Equipment Certification Program
Commercial Item Description	(CID)
A-A 59544	Cable and Wire, Electrical (Power, Fixed Installation)
ASTM International (ASTM)	
ASTM A27	Standard Specification for Steel Castings, Carbon, for General Application
ASTM A47	Standard Specification for Ferritic Malleable Iron Castings
ASTM A48	Standard Specification for Gray Iron Castings
ASTM A123	Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
ASTM A283	Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A536	Standard Specification for Ductile Iron Castings
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A897	Standard Specification for Austempered Ductile Iron Castings
ASTM C144	Standard Specification for Aggregate for Masonry Mortar
ASTM C150	Standard Specification for Portland Cement
ASTM C206	Standard Specification for Finishing Hydrated Lime
FAA Engineering Brief (EB)	
EB #83	In Pavement Light Fixture Bolts
Mil Spec	
MIL-P-21035	Paint High Zinc Dust Content, Galvanizing Repair
National Fire Protection Assoc	ciation (NFPA)
NFPA-70	National Electrical Code (NEC)

END OF ITEM L-115

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ITEM L-125 AIRPORT LIGHTING SYSTEMS

DESCRIPTION

125-1.1 This item shall consist of airport lighting systems furnished and installed in accordance with this specification, the referenced specifications, and the applicable advisory circulars (ACs). The systems shall be installed at the locations and in accordance with the dimensions, design, and details shown in the plans. This item shall include the furnishing of all equipment, materials, services, and incidentals necessary to place the systems in operation as completed units to the satisfaction of the RPR.

EQUIPMENT AND MATERIALS

125-2.1 GENERAL.

a. Airport lighting equipment and materials covered by Federal Aviation Administration (FAA) specifications shall be certified under the Airport Lighting Equipment Certification Program in accordance with AC 150/5345-53, current version. FAA certified airfield lighting shall be compatible with each other to perform in compliance with FAA criteria and the intended operation. If the Contractor provides equipment that does not performs as intended because of incompatibility with the system, the Contractor assumes all costs to correct the system for to operate properly.

b. Manufacturer's certifications shall not relieve the Contractor of their responsibility to provide materials in accordance with these specifications and acceptable to the RPR. Materials supplied and/or installed that do not comply with these specifications shall be removed, when directed by the RPR and replaced with materials, which do comply with these specifications, at the sole cost of the Contractor.

c. All materials and equipment used shall be submitted to the RPR for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Clearly mark each copy to identify pertinent products or models applicable to this project. Indicate all optional equipment and delete non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment for which they apply on each submittal sheet. Markings shall be clearly made with arrows or circles (highlighting is not acceptable). The Contractor shall be responsible for delays in the project accruing directly or indirectly from late submissions or resubmissions of submittals.

d. The data submitted shall be sufficient, in the opinion of the RPR, to determine compliance with the plans and specifications. The Contractor's submittals shall be submitted in electronic PDF format, tabbed by specification section. The RPR reserves the right to reject any or all equipment, materials or procedures, which, in the RPR's opinion, does not meet the system design and the standards and codes, specified herein.

e. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of at least twenty four (24)

months from final acceptance by the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner.

LED fixtures shall be provided with a 4 year warranty as required by EB 67. Any defective LED fixture shall be returned by the Contractor to the Supplier for repair or complete replacement for the first two years of the warranty period. Beyond two years into the warranty period, Reno will coordinate directly with the manufacturer for fixture replacement or repair.

125-2.2 CONDUIT/DUCT. Conduit shall conform to Specification Item L-110 Airport Underground Electrical Duct Banks and Conduits.

125-2.3 CABLE AND COUNTERPOISE. Cable and Counterpoise shall conform to Item L-108 Underground Power Cable for Airports.

125-2.4 TAPE. Rubber and plastic electrical tapes shall be Scotch Electrical Tape Numbers 23 and 88 respectively, as manufactured by 3M Company or an approved equal.

125-2.5 CABLE CONNECTIONS. Cable Connections shall conform to Item L-108 Installation of Underground Cable for Airports.

125-2.6 RETROREFLECTIVE MARKERS. Retroreflective markers shall be type L-853 and shall conform to the requirements of AC 150/5345-39.

125-2.7 RUNWAY AND TAXIWAY LIGHTS. Runway and taxiway lights shall conform to the requirements of AC 150/5345-46. Elevated light shall have an overall mounting height of 24". Lamps shall be of size and type indicated, or as required by fixture manufacturer for each lighting fixture required under this contract. Filters shall be of colors conforming to the specification for the light concerned or to the standard referenced.

Туре	Class	Mode	Style	Option	Base	Filter	Transformer	Notes
L-	2	1	3	Artic	12 inch	G/O	Per Mfg	New
852D(L)				Kit			_	Inpavement
L-	2	1	3	Artic	12 inch	W/W	Per Mfg	New
850A(L)				Kit				Inpavement
L-	2	1	N/A	Artic	12 inch	Blue	Per Mfg	New 24"
861T(L)				Kit				elevated
L-	2	1	3	Artic	12 inch	Blue	Per Mfg	New
850C(L)				Kit				Inpavement
L-	2	1	N/A	N/A	12 inch	Blue	Per Mfg	New
804(L)							_	elevated
L-	2	1	N/A	Artic	12 inch	Blue	Per Mfg	New 24"
862(L)				Kit				elevated
L-	2	1	3	Artic	12 inch	Blue	Per Mfg	New
862E(L)				Kit				Inpavement

Lights

125-2.8 RUNWAY AND TAXIWAY SIGNS. Runway and Taxiway Guidance Signs should conform to the requirements of AC 150/5345-44.

Signs

Туре	Size	Style	Class	Mode	Notes
L-858Y	3	5	2	2	New
L-858R	3	5	2	2	New
L-858L	3	5	2	2	New

125-2.9 RUNWAY END IDENTIFIER LIGHT (REIL). Not required.

125-2.10 PRECISION APPROACH PATH INDICATOR (PAPI). Not required.

125-2.11 CIRCUIT SELECTOR CABINET. Not used.

125-2.12 LIGHT BASE AND TRANSFORMER HOUSINGS. Light Base and Transformer Housings should conform to the requirements of AC 150/5345-42. Light bases shall be Type L-867 and L868, Class 1A, Size B and shall be provided as indicated or as required to accommodate the fixture or device installed thereon. Base plates, cover plates, and adapter plates shall be provided to accommodate various sizes of fixtures.

ISOLATION TRANSFORMERS. Isolation Transformers shall be Type L-830, size as required for each installation. Transformer shall conform to AC 150/5345-47.

INSTALLATION

125-3.1 INSTALLATION. The Contractor shall furnish, install, connect and test all equipment, accessories, conduit, cables, wires, buses, grounds and support items necessary to ensure a complete and operable airport lighting system as specified here and shown in the plans.

The equipment installation and mounting shall comply with the requirements of the National Electrical Code and state and local code agencies having jurisdiction.

The Contractor shall install the specified equipment in accordance with the applicable advisory circulars and the details shown on the plans.

125-3.2 TESTING. All lights and signs shall be fully tested by continuous operation for not less than 24 hours as a completed system prior to acceptance. The test shall include operating the constant current regulator in each step not less than 10 times at the beginning and end of the 24-hour test. The fixtures shall illuminate properly during each portion of the test.

125-3.3 SHIPPING AND STORAGE. Equipment shall be shipped in suitable packing material to prevent damage during shipping. Store and maintain equipment and materials in areas protected from weather and physical damage. Any equipment and materials, in the opinion of the RPR, damaged during construction or storage shall be replaced by the Contractor at no additional cost to the owner. Painted or galvanized surfaces that are damaged shall be repaired in accordance with the manufacturer's recommendations.

125-3.4 ELEVATED AND IN-PAVEMENT LIGHTS. Water, debris, and other foreign substances shall be removed prior to installing fixture base and light.

A jig or holding device shall be used when installing each light fixture to ensure positioning to the proper elevation, alignment, level control, and azimuth control. Light fixtures shall be oriented with

the light beams parallel to the runway or taxiway centerline and facing in the required direction. The outermost edge of fixture shall be level with the surrounding pavement. Surplus sealant or flexible embedding material shall be removed. The holding device shall remain in place until sealant has reached its initial set.

METHOD OF MEASUREMENT

125-4.1 3-MOD LIGHTED SIGN ON EXISTING FOUNDATION. The payment for furnishing and installing airfield guidance signs on existing foundations shall be measured per each and shall include but not be limited to the following work: sign, transformer, splice connector kits, cable between transformer and sign, secondary wire between transformer and sign, mounting plates, frangible couplings, mounting legs, bolts, epoxy, cutting existing anchors, adding additional concrete to existing foundation, testing, commissioning, and all other work, material, and labor required to install the sign to the full satisfaction of the engineer. The contractor shall be paid separately for each type and number of modules of a sign. Note; sign shall be LED (L).

125-4.2 PANEL (ANY LENGTH) ON EXISTING SIGN (FOR MAGVAR). The payment for installing new sign panels on existing signs shall be measured per each and shall include but not be limited to the following work: sign panel, removal of existing panels, sign ribs, hardware, cleaning sign inside and out, and all other work, material, and labor required to install the sign panels to the full satisfaction of the engineer. The contractor shall be paid the same for each type and number of modules of a sign.

125-4.3 L-868B BASE CAN WITH EXTENSION. The base can shall be paid at the contract unit price for each light base can installed, complete in place, and accepted by the Engineer. This cost for this bid item includes removal of existing base can, excavation, coring and concrete encasement for new base can, base can, extension, rebar cage, ground rod, grounding, alignment jig, and all other appurtenances required to complete the installation of the base can. Note; as part of base can removal and associated panel removal, the contactor shall assume at least a ¹/₂ cubic yard minimum void in the subgrade around the base can will need to be removed and installed with new P-610 or compacted back with native fill to 98% compaction.

125-4.4 L-867B BASE CAN. The base can shall be paid at the contract unit price for each light base can installed, complete in place, and accepted by the Engineer. This cost for this bid item includes removal of existing base can, excavation, coring base can, and concrete encasement for new base can, rebar cage, ground rod, grounding, alignment jig, and all other appurtenances required to complete the installation of the base can. Note; as part of base can removal, the contactor shall assume at least a ½ cubic yard minimum void in the subgrade around the base can will need to be removed and installed with new P-610 or compacted back with native fill to 98% compaction.

125-4.5 L-867D JUNCTION CAN WITH COVER PLATE. Payment for new L867D Junction Can with Cover Plate will be made at the contract unit price for each junction can installed, complete in place, and accepted by the Engineer. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item. The cost of this bid item shall include the (a) L867D base can (b) cover plate (c) bolts, (d) washers, (e) grounding wire and connections, (f) excavation, (g) concrete backfill and all other appurtenances required to complete each junction can per the details.

125-4.6 NEW RUNWAY ELEVATED LIGHT FIXTURES. This paragraph details the method of measurement for for runway elevated edge lights. Payment for new light fixtures (any type)

will be made at the contract unit price for each type of light fixture installed, complete in place, and accepted by the Engineer. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item. The cost of this bid item shall include but not be limited to: (a) light fixture, base plate, lamp, frangible coupling, pole, and (b) transformer(s), (c) bolts, o-ring, and washers, (d) grounding wire and connections, (e) removal of existing light fixture, transformer, and all other appurtenances required to complete the installation of the light. All materials and equipment shall be new. Payment shall be the same regardless of color configuration for the runway lights. Note; this bid item does not cover the reinstallation of the elevated runway guard light L-804 which is bid separately. Note; the cost of furnishing a quartz style runway elevated edge or end/threshold light is included in this bid item. The cost for the LED light is bid separately. However, this bid item shall cover the cost of installing either a LED or quartz light.

125-4.7 NEW TAXIWAY ELEVATED LIGHT FIXTURES. This paragraph details the method of measurement for taxiway elevated edge lights. Payment for new light fixtures (any type) will be made at the contract unit price for each type of light fixture installed, complete in place, and accepted by the Engineer. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item. The cost of this bid item shall include but not be limited to: (a) light fixture, base plate, lamp, frangible coupling, pole, and (b) transformer(s), (c) bolts, o-ring, and washers, (d) grounding wire and connections, (e) removal of existing light fixture, transformer, and all other appurtenances required to complete the installation of the light. All materials and equipment shall be new. Payment shall be the same regardless of color configuration for the runway lights. Note; this bid item does not cover the reinstallation of the elevated runway guard light L-804 which is bid separately. Note; the taxiway edge lights shall be LED (L).

125-4.8 NEW RUNWAY CENTERLINE OR TAXIWAY CENTERLINE IN-PAVEMENT LIGHT FIXTURES. This paragraph details the method of measurement for runway centerline and taxiway centerline lights. Payment for new light fixtures (any type) will be made at the contract unit price for each type of light fixture installed, complete in place, and accepted by the Engineer. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item. The cost of this bid item shall include but not be limited to: (a) light fixture and transformer(s), (b) bolts, (c) washers, (d) grounding wire and connections, (e) removal of existing light fixture, transformer, spacers, and accessories, and (f) coring, (g) spacer rings and flange ring with pavement dam, sealant, id tags, all other appurtenances required to complete the installation of the light and adjust spacer and flange rings to the correct grade. All materials and equipment shall be new. Payment shall be the same regardless of color configuration. Note; new lights shall be LED (L).

125-4.9 NEW RUNWAY EDGE IN-PAVEMENT LIGHT FIXTURES. This paragraph details the method of measurement for all new runway edge in-pavement light fixtures. Payment for new light fixtures (any type) will be made at the contract unit price for each type of light fixture installed, complete in place, and accepted by the Engineer. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item. The cost of this bid item shall include but not be limited to: (a) light fixture and transformer(s), (b) bolts, (c) washers, (d) grounding wire and connections, (e) removal of existing light fixture, transformer, spacers, and accessories, and (f) coring, (g) spacer rings and flange ring with pavement dam, sealant, id tags, all other appurtenances required to complete the installation of the light and adjust spacer and flange rings to the correct grade. All materials and equipment shall be new. Payment shall be the same regardless of color configuration.

Note; the cost of furnishing a quartz style runway elevated edge or end/threshold light is included in this bid item. The cost for the LED light is bid separately. However, this bid item shall cover the cost of installing either a LED or quartz light.

125-4.10 REINSTALL ELEVATED RUNWAY GUARD LIGHTS. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item. The cost of this bid item shall include but not be limited to: (a) removal of existing fixture and storage for later reinstallation, (b) installation of existing fixture on new or existing base can with new bolts, washers, fixture ID tags, (c) id tags, (d) aligning the fixture in accordance with FAA 150/5340-30, and all other appurtenances required to complete the installation of the light and adjust spacer and flange rings to the correct grade.

125-4.11 NEW RETROREFLECTIVE MARKER. This paragraph details the method of measurement for all new retroreflectors. Payment for reflector will be made at the contract unit price for each type of retroreflective marker installed, complete in place, and accepted by the Engineer. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item. The cost of this bid item shall include but not be limited to: the retroreflector, adhesive, preparation, and all other appurtenances required to complete the installation of the marker. All materials and equipment shall be new.

125-4.12 NEW L-858 GUIDANCE SIGN AND FOUNDATION. The payment for furnishing and installing airfield guidance signs on new foundations shall be measured per each and shall include but not be limited to the following work: sign, excavation, rebar, asphalt, base can for the sign, cover plate, conduit, J-bolts, concrete backfill, maintenance and housekeeping pad, transformer, splice connector kits, cable between transformer and sign, secondary wire between transformer and sign, mounting plates, frangible couplings, mounting legs, bolts, epoxy, testing, commissioning, and all other work, material, and labor required to install the sign to the full satisfaction of the engineer. The contractor shall be paid separately for each type and number of modules of a sign. However, payment shall be the same for a single sided or double-sided sign. Note; new sign shall be LED (L).

125-4.13 ADDITIONAL COST TO FURNISH L-862(L), L-862E(L), AND L-850C(L) LED RUNWAY LIGHTS. The payment for furnishing L-862(L), L-862E(L), and L-850C(L) shall be measured per lump sum. This bid item covers the additional cost required to furnish LED lights for the runway edge lighting system instead of the quartz lights. Note; this bid item covers only the material cost as the installation cost shall be the same and covered in a different bid item. Note; the quantity of lights shall match the quantity of lights detailed in bid items L-125-6, L-125-7, and L-125-8 but the contractor shall be paid lump sum for the difference in material cost.

BASIS OF PAYMENT

125-5.1 Payment will be made at the Contract unit price for each complete runway or taxiway light, guidance sign, reflective marker, runway end identification light, precision approach path indicator, or abbreviated precision approach path indicator installed by the Contractor and accepted by the RPR. This payment will be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools and incidentals necessary to complete this item.

Payment will be made under:

L-125-1	3-Mod Lighted Sign(L) on Existing Foundation	Per Each
L-125-2	Panel (Any Length) on Existing Sign (for MagVar)	Per Each
L-125-3	L-868B Base Can w/ Extension	Per Each
L-125-4	L-867B Base Can	Per Each
L-125-5	L-867D Junction Can with Cover Plate	Per Each
L-125-6	L-862E Runway End/Threshold Light	Per Each
L-125-7	L-862 Runway Elevated Edge Light	Per Each
L-125-8	L-850C Runway Inpavement Edge Light	Per Each
L-125-9	L-861T(L) Taxiway Elevated Edge Light	.Per Each
L-125-10	Reinstall L-804 Elevated Runway Guard Light	Per Each
L-125-11	L-853 Retroreflective Marker	Per Each
L-125-12	RDR(L) Sign on New Foundation	.Per Each
L-125-13	1-Mod Lighted Sign(L) on New Foundation	Per Each
L-125-14	2-Mod Lighted Sign(L) on New Foundation	Per Each
L-125-15	3-Mod Lighted Sign(L) on New Foundation	Per Each
L-125-16	4-Mod Lighted Sign(L) on New Foundation	Per Each
L-125-17	L-850A(L) Runway Centerline Light	.Per Each
L-125-18	L-852D(L) Taxiway Centerline Unidirectional Light	Per Each
L-125-19	L-852D(L) Taxiway Centerline Bidirectional Light	Per Each
L-125-20	Additional Cost to Furnish L-862(L), L-862E(L), and	
	L-850C(L) LED Runway Lights	Lump Sum

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Advisory Circulars (AC)

AC 150/5340-18	Standards for Airport Sign Systems
AC 150/5340-26	Maintenance of Airport Visual Aid Facilities
AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-5	Circuit Selector Switch
AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
AC 150/5345-26	Specification for L-823 Plug and Receptacle, Cable Connectors
AC 150/5345-28	Precision Approach Path Indicator (PAPI) Systems

AC 150/5345-39	Specification for L-853, Runway and Taxiway Retroreflective Markers
AC 150/5345-42	Specification for Airport Light Bases, Transformer Housings, Junction Boxes, and Accessories
AC 150/5345-44	Specification for Runway and Taxiway Signs
AC 150/5345-46	Specification for Runway and Taxiway Light Fixtures
AC 150/5345-47	Specification for Series to Series Isolation Transformers for Airport Lighting Systems
AC 150/5345-51	Specification for Discharge-Type Flashing Light Equipment
AC 150/5345-53	Airport Lighting Equipment Certification Program
Engineering Brief (EB)	
EB No. 67	Light Sources Other than Incandescent and Xenon for Airport and Obstruction Lighting Fixtures

END OF ITEM L-125

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SECTION L-128

DEMOLITION & REMOVAL OF AIRFIELD LIGHTING, TEMORARY AIRFIELD LIGHTING WORK, AND MISCELLANEOUS AIRFIELD LIGHTING WORK

DESCRIPTION

128-1.1 GENERAL. This item shall include the demolition and removals of existing airfield electrical equipment and facilities for all areas within the limits of construction as provided in these specifications, as shown on the Drawings, or as required by the Engineer.

EQUIPMENT AND METHODS

128-2.1 GENERAL. Objects, surfaces and items including the underground utilities designated to remain shall be carefully avoided and left undisturbed. Any damage to these items shall be immediately corrected by the Contractor to the satisfaction of the Engineer.

128-2.2 EQUIPMENT. Equipment used in conjunction with this work shall be in first class working condition and shall be capable of removing the material in an efficient manner.

128-2.3 SALVAGEABLE ITEMS. The airport has the right of first refusal of all light fixtures, signs, transformers, LIR poles, and electronic junction cans. This equipment that is designated to be salvaged will remain the Department of Airport's property at a designated salvage area. These items shall be carefully removed and shall be delivered to the Airport's maintenance yard and stockpiled in a neat orderly fashion as directed by the Engineer. If it is determined that through the Contractor's operations of removing and handling, these items are being damaged, the Engineer reserves the right to withhold payment from the Contractor for compensation of these items. All other equipment shall removed off airport property at the contractor's own expense and disposed off in accordance with applicable state rules and regulations.

128-2.4 **REMOVAL**

- a. **CABLE REMOVAL**. All the existing cables to be removed shall become the property of the Contractor to be promptly removed from the airport property. Temporary storage of these items on airport property shall be subject to the approval of the Engineer. The contractor shall assume that the length of cable to be removed shall equal 130% of the amount of new cable to be installed.
- b. **CONDUIT, REMOVAL AND ABANDONMENT**. Existing conduit shall be removed as shown on the Drawings, or as directed by the Engineer. Removed items shall become the property of the Contractor and shall be promptly removed from airport property. Conduit designated to be abandoned in place shall be capped on each end as approved by the Engineer with existing cable to be removed. Where conduit comes to the surface, the conduit shall be cut back to minimum one (1) foot below ground, final grade, and capped.
- c. **DUCTBANK, REMOVAL AND ABANDONMENT**. Existing ductbank shall be removed as shown on the Drawings, or as directed by the Engineer. Removed items shall become the property of the Contractor and shall be properly removed and disposed off Airport property. At locations, defined in the construction drawings, the ductbank may contain asbestos cement (A-C) pipe (sometimes referred to as "transite").

- d. **REMOVAL OF EXISTING BASE CANS**. Base Cans shall be removed as detailed on the construction drawings.
- e. **REMOVAL OF GUIDANCE SIGNS**. Guidance signs shall be removed as indicated on the drawings. Coordinate with the Construction Manager for turnover location of signs. Any signs Reno or the Construction Manager decides not worthy to salvage must be disposed off site by the contractor. The sign foundation, base can and infrastructure shall be removed and the hole backfilled and compacted with native soil.

f. **REINSTALLATION OF LIGHT FIXTURE OR OTHER ELECTRICAL EQUIPMENT**. Prior to performing any demolition work, the Contractor shall perform a visual inspection (with lights turned off and on) in conjunction with the Airport to determine if any of the light fixtures are missing, damaged, or have a burned-out lamp. This visual inspection shall be performed during the day and at night with the light fixtures powered on, and the Contractor shall provide the Engineer with a written document detailing the deficiencies found. If any of the light fixtures are damaged or lost during the construction project, the Contractor shall replace the damaged or lost light fixture with a new, equal or approved equal light fixture at the Contractor's own expense.

Light Fixtures that require removal shall be salvaged and delivered to the Owner's Department of Maintenance, the Contractor shall protect the leads by curling them and then taping them to the bottom side of the fixture housing. The fixture shall be placed inside a circular plastic tube that is the diameter (circumference) of the light and approximately 3" tall.

128-2.5 TEMPORARY AIRFIELD LIGHTING. Contractor shall provide all cables, conduits, fixtures, and temporary CCR connections at the Airfield Lighting Vaults to provide temporary airfield lighting required to maintain the function of the airfield during all stages of reconstruction. This shall include all necessary splices at manholes as shown on the drawings to ensure that the circuits are operational at other areas of the airfield during the entire construction period.

128-2.6 REROUTING NEW CIRCUIT CONFIGURATIONS AND OPENING BASE CANS, HANDHOLES, AND MANHOLES. Prior to start of the demolition work, the Contractor shall open all necessary base cans, handholes, and/or manholes to ascertain and provide the Engineer in writing a schematic wiring diagram showing the number of cables and circuits in existing light base configuration. This item includes pumping and removing the water that may be located inside the handholes and manholes. The Contractor shall assume that all handholes shown in the project area and layout drawings must be opened and pumped of water to ensure circuit continuity.

128-2.7 OTHER ITEMS. Items to be removed not listed above shall be removed from airport property by the contractor unless otherwise directed by the Engineer. Any questionable items shall be brought to the Engineer's attention, which will direct the Contractor for final disposition of the item.

METHOD OF MEASUREMENT

128-3.1 Demolition and Removal of Electrical Work shall be paid for as a lump sum amount. This work shall include but not be limited to the following: (a) Removal and coring of base cans as required, (b) removal of existing electrical structures, (c) removal of cable, handholes/manholes, ground test wells, grounding, and all other work required to remove the existing electrical appurtenances as shown in the drawings.

128-3.2 Temporary Airfield Electrical Work shall be paid for as a lump sum amount. This work shall include but not be limited to the following: Temporary cable, conduit, looping circuits out, blanking/covering signs, and any other temporary work to prepare the airfield system for each phase and as shown on the plans.

128-3.3 Miscellaneous Airfield Electrical Work shall be paid for as a lump sum amount. This work shall include but not be limited to the following:

- **a.** Grounding of existing light fixtures
- **b.** Retapping of bolts up to 15% of all existing bolts,
- **c.** Coordination with civil contractor

d. Coordination with ADB, manufacturer of the ALCS. This includes all markup, overhead, taxes and insurance required to coordinate, escorte and hire ADB.

- e. Circuit Investigation and providing schematic diagrams for circuit investigation prior to installation of new cable.
- f. As-Builts,
- g. Shop Drawings,
- **h.** Providing schematic diagrams for circuit investigation,
- i. Cable butterflies (elevations of each handhole side) details of handhole/manholes, cleaning handholes, photographs of walls and floors, pumping out water (regardless of number of times required to enter handhole/manhole), confined space permit as required, and
- **j.** All the material, equipment, labor, and coordination necessary to complete the airfield lighting work shown in the construction drawings and described herein and not covered for under other bid items.

BASIS OF PAYMENT

Payment shall be made as follows:

Item L-128-1	Demolition and Removal of Electrical Work	Per Lump Sum
Item L-128-2	Temporary Airfield Electrical Work	Per Lump Sum
Item L-128-3	Miscellaneous Airfield Electrical Work	Per Lump Sum

END OF SECTION L-128

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ITEM L-132 RUNWAY SURFACE CONDITION SENSOR SYSTEM

DESCRIPTION

132-1.1 GENERAL. This item shall consist of furnishing and installing new material and components for the airport surface condition sensor as supplied by Vaisala Inc. and in accordance with these Specifications and in accordance with the dimensions, design and details shown in the Drawings as well as the recommendations of the equipment manufacturer. This item shall include the furnishing of all equipment, materials, services and incidentals necessary to place the system in operation as completed units to the satisfaction of the Construction Manager. Conduits, duct banks, trenching, and cabling to complete the system operation will be included as part of this specification. Contact for furnishing the equipment is

Eric Paulk (Sales Manager) Vaisala, Inc., <u>194 South Taylor Ave</u>, Louisvillle, CO 80027 Tel <u>(720) 237-8586</u> <u>eric.paulk@vaisala.com</u> <u>http://www.vaisala.com/</u>

132-1.2 SUBMITTALS. Shop drawings of each pavement sensor system component shall be submitted to the Construction Manager for review and approval and be approved prior to ordering any materials for this item. This submittal shall include the proposed method of installation for all components. The submittal shall include data on all component parts of the item or system. The data submitted shall be sufficient, in the opinion of the Construction Manager, to determine compliance with the Contract Documents. The Contractor's submittal shall be in accordance with Item L-100.

132-1.3 QUALIFICATIONS. The Construction Manager reserves the right to reject any and all equipment, materials or procedures which, in the Construction Manager's opinion, does not meet the system design and the standards and codes specified herein.

EQUIPMENT AND MATERIALS

132-2.1 GENERAL.

a. All equipment and materials covered by other referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification when requested by the Construction Manager.

b. All items not specified in these specifications or shown on the construction plans, but recognized to be required and involved in carrying out the system installation shall be included and performed as though they were specifically delineated, described and mentioned.

132-2.2 GUARANTEES. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of 24 months or

the manufacturer's standard guarantee period whichever is greater, from final acceptance by Reno. The defective materials and/or equipment shall be replaced with no additional cost to Reno.

132-2.3 CONDUIT. Conduit shall conform to Item L-110 "Airport Underground Electrical Duct."

132-2.4 CONCRETE. Concrete and steel reinforcement shall conform to Item P-610 "Structural Portland Cement Concrete."

132-2.5 WIRE. Power wire and cable shall be in accordance with Item L-108 "Installation of Underground Cable for Airports" unless otherwise required by the manufacturer for proper operation of the system.

132-2.6 MULTI-PAIR CONTROL CABLE (SURFACE SCAN SENSOR CABLE TYPE V). Multi-pair control cable shall conform to DIN VDE 0812, Equipment Wires and Stranded Equipment Wires for Telecommunications Systems and Data Processing Systems, and DIN VDE 0814, Cords for Telecommunication Systems and Information Processing Systems, color coded to DIN 47100, International Electrotechnical Commission (IEC) 60228 Class 5, Conductors of Insulated Cables. The cable shall be 6-twisted pairs, No. 19 (30/30) AWG bare copper with tinned copper wire shield, PVC core insulation and PVC outer jacket, 250V minimum working voltage. Also referenced as LiYCY TP.

132-2.7 CONTROL CABLE SPLICES. Control cable splices shall consist of a pressure cast splice, employing a plastic mold and using epoxy resin equal to that manufactured by Minnesota Mining and Manufacturing (3M) Company, "Scotchcast" electrical insulating resin No. 4 for potting the splice is approved. Connections of cable and connectors shall be made using crimp connectors utilizing a crimping tool designed to make a complete crimp before the tool can be removed. No. 19 AWG telecommunications control wires may be connected by means of wrapped and soldered splice, Vaisala 24051020 Splice kit, 3M Company Moisture Proof UR type connector, or equal, or by a method approved by the Construction Manager. This means of splicing is the only type approved for telecommunications control cable.

132-2.8 BASE CAN. Base cans shall be in accordance with Item L-125 "Airport Lighting Systems."

132-2.9 SURGE ARRESTER. At each Remote Processing Unit (RPU) site a surge arrester designed for 120/240 volts, 60Hz, 1 phase, 3 wire plus ground, all mode protection shall be supplied. All components shall be installed in a NEMA 4 with a hinged cover. Indicator lights shall be installed in the front cover to show when power is normal and when a device has failed. The surge suppressor shall be U.L. Listed under Standard No. 1449 or be approved by the Federal Aviation Administration. Written verification of approval shall be submitted.

Breakdown Voltage:

(Turn On Threshold): 120V + 10% maximum operating (clamping) voltage.

Operating Time: Less than 1 nanosecond.

a. Maximum Surge Current (8 x 20 microsecond): 80 KA per mode, minimum.

Fuses: Each surge suppression device shall be fused and there shall be no series devices in the power line.

Field Replacement: All fuses and surge suppression devices shall be field replaceable.

Terminals: Terminals shall securely hold #8 AWG copper wire.

132-2.10 OBSTRUCTION LIGHT. The obstruction lights shall conform to the requirements of AC 150/5345-43, Specification for Obstruction Lighting Equipment. The steady-burning obstruction light shall be type L-810, steady burning, LED, dual unit, operating from a 120V circuit.

132-2.11 RECEPTACLE. The Contractor shall provide a specification grade, 15A duplex GFCI receptacle. The receptacle shall meet the requirements of Federal Specification WC596. The receptacle shall include red LED trip indicator light and 10kA short circuit rating. Mount the receptacle in a cast box with an in-use metal cover.

132-2.12 RUNWAY PAVEMENT SURFACE CONDITION SYSTEM – EQUIPMENT TO BE FURNISHED BY MANUFACTURER.

a. **Remote Processing Unit (RPU).** The contractor shall supply and install a rack mounted RPU electronics package with enclosure as noted on the Plans. The RPU shall be enclosed inside a NEMA 4 lockable enclosure that is resistant to damage by weather. It shall be mounted on a freestanding, non-climbable, corrosion resistant, rack.

The RPU hardware and software supplied for the project shall meet the following technical specifications. Each RPU shall collect data from sensor arrays that are shown on the drawings. There will be a total of fifteen sensor arrays for the complex.

RPU communication will be via wireless cell modem service to the supplier's Online Web site and shall utilize the most current published Federal Standard NTCIP-ESS protocol, with some manufacturer specific objects. The web site will poll the RPU via the IP addressable modem. The RPU shall incorporate "watch-dog" circuitry and monitor its own operation and reset itself if the RPU software enters an indeterminate state. The RPU shall also have the capability to be reset by a "user administrator" from the server.

The manufacturer of the surface scan sensor shall furnish the following materials:

- i. RPU # 1 & 6 Components:
 - 1) RWS200 RPU including but not limited to;
 - 2) HMP155 Air Temperature / Relative Humidity Sensor
 - 3) WMT700 Ultrasonic WS/WD Sensor
 - 4) PWD22 Precipitation/Visibility Sensor
 - 5) PTB110 -- Pressure sensor
 - 6) DRS511 In-pavement sensor
 - 7) DTS12G Temperature Subprobe (RPU# 1 Only)
 - 8) Modem Router Digi Trans Port (WR-21M)

- 9) Mounting frame for installation into an aluminum RPU Cabinet
- 10) NEMA 4 RPU
- 11) Airport Mounting Structure
- 12) Dual Obstruction LED Lights
- ii. RPU # 3 & 5 Components:
 - 1) RWS200 RPU including but not limited to;
 - 2) HMP155 Air Temperature / Relative Humidity Sensor
 - 3) PTB110 -- Pressure sensor
 - 4) DRS511 In-pavement sensor
 - 5) DTS12G Temperature Subprobe (RPU# 5 Only)
 - 6) Modem Router Digi Trans Port (WR-21M)
 - 7) Mounting frame for installation into an aluminum RPU Cabinet
 - 8) NEMA 4 RPU
 - 9) Airport Mounting Structure
 - 10) Dual Obstruction LED Lights

b. User Interface. The Manufacturer shall provide an Internet Hosted Web Site, RSCSS Online Navigator and provide access to RSCSS data using a widely available Internet browser (Internet Explorer). Access and display of current and historical RSCSS sensor data, and forecast data resident on hosted Web site shall be available.

c. Sensing Equipment:

- 1. Pavement Sensors. Provide sixteen (16) DRS511 pavement sensors
- 2. Provide Two (2) DTS12G Temperature Probes
- **3.** Provide Type 5 Sensor Cable and all associated splice connections.

All other equipment including, foundation, mounting poles, unistruts, and all other materials and appurtenances shall be furnished and installed by the contractor.

132-2.13 RUNWAY PAVEMENT SURFACE CONDITION SYSTEM – EQUIPMENT TO BE FURNISHED BY CONTRACTOR

a. Contractor shall supply foundation, unitstrut, mounting pole, transformer, disconnect switch, and all other appurtenances required to complete the work but not provided for by the manufacturer. Note; the contractor shall also be responsible for hiring the manufacturer of the surface scan sensor to commission and calibrate the equipment as well as escorting the manufacturer on/off jobsite. Contractor shall contact the manufacturer prior to the bid to obtain, in writing, escort and management requirements as well as shop drawings of equipment.

b. Contractor shall install the surface scan sensor Type V cable, the pavement sensors, and the temperature probe as required.

c. Contractor shall be a certified, authorized contractor by Vaisala, Inc. and shall submit certification as part of the shop drawing.

CONSTRUCTION METHODS

132-3.1 GENERAL. Prior to start of any construction, a coordination meeting between the Airport, Construction Manager, Contractor, and Manufacturer should be scheduled. The meeting should as a minimum discuss phasing of work, responsibilities of each party, sensor and cable installation requirements, and scheduling of work.

The Contractor shall furnish and install surface condition sensors as shown on the Plans. Installation of the sensors, cabling between sensors and RPU, and installation of the RPU itself shall be in accordance with the Plans, recommendations of the manufacturer and all federal, state and local codes. Each sensor shall have its own individual cable. The sensor cables shall be continuous between the RPU and each sensor and shall have no cable connector kits installed except for the passive pavement sensors.

132-3.2 COMMISSIONING. After completion of the surface scan sensor system equipment installation, the system vendor shall provide an on-site field engineer to start-up and test the entire system. The vendor's field engineer will make all final sensor connections to the RPU, perform all final system checks, sensors connectivity, functionality and alignments. Insure continuous data flow via 4G cellular modem. Verify connectivity of IP addressable data management units with manufacture server. Vendor shall integrate 4 new RPU into existing software Web interface of Reno International Airport weather system verify mapping gps locations of new sensors . Verify back up battery functionality and main power loss reporting. Perform software configuration to provide a fully operational system. Vendor shall assume that a minimum of 10 days on-site will be required.

A four-hour on-site training course of the system shall take place after the system is operational and tested.

132-3.3 GROUND CONNECTION AND GROUND ROD. The Contractor shall furnish and install ground rods, grounding cable, and exothermic welds for grounding the frame of the assembly near the base. The ground rods shall be 3/4-inch diameter by 10 feet long and shall be copper or copper-clad steel.

132-3.4 MAINTENANCE MANUALS. The Contractor shall provide data for all equipment, material and components supplied or furnished under this section in the Operation and Maintenance Manuals. This data shall include cut sheets from the manufacturer and the manufacturer's installation, operation and maintenance manuals, recommended spare parts lists, any required test results, and other data. Final payment for any contract amounts shall not be processed without proper submittal of these manuals and review and approval by the Construction Manager.

METHOD OF MEASUREMENT

132-4.1 Install RPU Enclosure and Electronics Equipment. This bid item shall be measured by a lump sum cost, complete in place, ready for operation, and accepted as satisfactory by the Engineer. This work includes but not limited to: testing, securing, and coordination of manufacturer for their services to commission the system, coordination with Reno, furnishing and installing all hardware, grounding, transformer, disconnect, enclosure, strut, and all the material, equipment, labor and coordination necessary to complete the work shown in the construction drawings and described herein, complete in place and to the full satisfaction to the Engineer. This bid item does not include furnishing

the equipment detailed in paragraph 132-2.12, but does include installation of the material per manufacturer recommendations. Note; this bid item does not include surface scan cable which shall be bid in paragraph 132-4.2. Contractor shall contact manufacturer prior to the bid to obtain all requirements, details, installation notes, and scheduling requirements. This bid item includes the demolition and removal of existing RPUs.

132-4.2 Install Surface Scan Sensor Cable – Type V. The surface scan cable shall be measured by linear foot, complete in place, ready for operation, and accepted as satisfactory by the Engineer. The cost of the cable shall include removal of existing cable, mandrel of conduit, furnishing and installation of new cable and any splice connections required. Contractor shall contact the manufacturer of the surface scan sensory equipment to ascertain pulling tensions prior to the bid. Cost to furnish the cable shall be provided by the manufacturer under bid item L-132-4. Note; this bid item is provided as an allowance to cover unforeseen conditions and the contractor shall hold the price regardless of a quantity deviation from 0% to 200% of bid quantity.

132-4.3 Install Pavement Surface Sensor System. The installation of the pavement sensors and temperature probe shall be measured by lump sum cost, complete in place, ready for operation, and accepted as satisfactory by the Engineer. The cost of the bid item shall include but not limited to: (a) removal and abandonment of existing pavement sensors, (b) installation of all pavement sensors and temperature probe, (c) connections, (d) testing, (e) kerf, backer rod, backfill, sealant and pigtail wire between the sensor and nearest junction can and/or handhole, and commissioning and all other appurtenances required to provide a fully functional system. Contractor shall contact the manufacturer of the surface scan sensor equipment to ascertain pulling tensions prior to the bid. Cost for furnishing the sensors and temperature probe shall be provided by manufacturer under bid item L-132-4.

132-4.4 Furnishing RPU, Pavement Sensor, Temperature Probe and Associated Equipment and Commissioning (Manufacturer). This bid item shall be measured by a lump sum cost furnished and shipped to the contractor's site at the airport. The equipment shall be furnished by the manufacturer (Vaisala) and shall include all equipment detailed in paragraph 132-2.12 in this specification as well as the cost of commissioning and integration of the system including on-site work, testing, and training. Bid item includes all taxes, overhead, and cost from the manufacturer.

BASIS OF PAYMENT

Payment shall be made in accordance with the following items:

L-132-1	Install RPU Enclosure and Electronics Installation	Lump Sum
L-132-2	Install Surface Scan Sensor Cable - Type V	Linear Foot
L-132-3	Install Pavement Surface Sensor System	Lump Sum
L-132-4	Furnishing Surface Scan Sensor(s), Cable and RPU Equipment (By Manufacturer Cost)	Lump Sum

END OF ITEM L-132
ITEM L-146 – FAA MALSR SYSTEM MODIFICATIONS

PART 1 - DESCRIPTION

1.1 GENERAL. The Contractor shall perform all work required by the plans for removal, modification, and construction of the 16R and 34L Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR) as shown on the plans and as described herein.

This specification covers the minimum requirements for civil and electrical work, which may include: removal and disposal of existing equipment, cables, foundations, and pull boxes; providing and installing material, equipment, duct bank, pull boxes, conduits, power cabling, and appurtenant equipment; construction of foundations; miscellaneous incidentals; and all other items required to complete the system, including testing.

The MALSR is owned and operated by the Federal Aviation Administration (FAA). Following acceptance of Contractor's work by the Engineer and the FAA, the completed MALSR system will be Flight Checked and commissioned by the FAA.

The Contractor shall provide all work required for a complete, functioning, and tested MALSR system, complete in place and accepted by the Engineer. Any items and/or work not specifically called out on the plans or specifications, but which is required to complete the installation in order to result in a complete, functioning and approved MALSR, will be considered incidental to the appropriate bid item and no separate payment will be made.

Because of the specialized nature of this work, the Contractor or subcontractor performing the work shall be required to have at least 5 years verifiable experiences installing and modifying airfield lighting or FAA NAVAID electrical systems.

- **1.2 DEFECTIVE WORK.** Any work performed under this section which fails to meet the requirements stated herein will be considered defective and, unless another remedy is stated, shall be removed and replaced at the Contractor's expense.
- **1.3 LIMITED ACCESS / NIGHT CONSTRUCTION.** See the construction phasing drawings for restrictions relative to construction in areas of limited or night-time construction.
- **1.4 FAA CONTACTS.** All work to be performed under this section shall be coordinated with the FAA at all stages of the construction. The Local FAA Contact will be designated by the SSC (Systems Service Center).

PART 2 - EQUIPMENT AND MATERIALS

2.1 GENERAL. Provide all materials as stated in manufacturer's technical specifications or as called out on the drawings or in the specifications.

Installation shall be in accordance with the Plans, Specifications, and FAA Order C-1391, except as specified herein.

Install shall be in accordance with Plans, Specifications, and FAA Order FAA-STD-19. Except as specified herein.

2.2 LIGHT FIXTURES.

- **A.** In-pavement, non-threshold fixtures. Semi-flush in-pavement, non-threshold, lights shall be qualified to FAA-E-2968 as manufactured by Multi-Electric, model number 3950-4 (MALS White, Style I).
- **B.** In-pavement, threshold fixtures. Semi-flush in-pavement, threshold, lights shall be qualified to FAA-E-2968 as manufactured by Multi-Electric, model number 3950-5 (MALS Green, Style II).
- **2.3 ISOLATION TRANSFORMERS.** Isolation transformers installed with in-pavement MALSR light fixtures shall be 180-watt, 240 volt / 27.3 volt type transformers or approved equal. The transformers shall have factory molded L-824 plugs and receptacles with two primary leads and one secondary lead.
- 2.4 LIGHT BASES, FLANGE RINGS, SHIMS, AND EXTENSIONS. Light bases, snow plow rings, shims and extensions shall meet the requirements of FAA AC 150/5345-42, current version & Engineering Brief 85.
 - A. Light bases shall be L-868, size C, nominal 15-inch diameter, 24 inches deep, unless specified otherwise on the drawings.
 - **B.** Snow plow rings shall be designed to fit semi-flush lighting fixtures. The snow plow ring shall be sized for nominal 15-inch diameter L-868 base cans.
 - **C.** Shims of varying thicknesses shall be supplied by the Contractor to accommodate final adjustment of in-pavement base can installations. The shims shall be sized for nominal 15-inch diameter L-868 base cans.
 - **D.** Light base top sections (extensions) shall be sized for nominal 15-inch diameter L-868 base cans and of the thicknesses to accommodate paving operations and Contractor installation method.
- **2.5 POWER CABLE.** Power cable for the MALSR system shall be the following:
 - **A.** For underground applications: 600V, stranded uncoated copper wire, with insulation rating of USE-2/XLP (wet location rated to 90 degree Celsius), sized as shown on the drawings.
 - **B.** For above ground applications: 600V, stranded uncoated copper wire, with insulation rating of THWN, #12 minimum and sized as shown on the drawings.
- **2.6 COMMUNICATION CABLE.** Communication cable for the MALSR system shall be type PE-39, 19AWG 6 pair gel filled cable with copper shielding; Manufacture General Cable or approved equal.
- 2.7 **INSULATED EQUIPMENT GROUND WIRE.** Grounding conductors shall be stranded copper wire, with green insulation rating as specified in Paragraph 2.5 and sized as shown on the drawings.

2.8 BARE COPPER WIRE (COUNTERPOISE OR GROUND) AND GROUND RODS.

- A. Guard wire over conduit in trench shall be stranded, #1/0 bare copper wire. The guard wire shall be exothermically-welded to existing counterpoise and to each ground rod along conduit run.
- **B.** Guard wire connection wire between a ground rod, base can, pull box or other device shall be stranded, # 6 bare copper wire. The guard wire shall be exothermically-welded to the connection wire.
- C. Ground rods shall be copper-clad steel. The ground rods shall be 10-feet long and 3/4-inch diameter.

- **2.9 CABLE CONNECTIONS.** All connections shall be per FAA Specification C-1391b, Installation and Splicing of Underground Cables and of the type listed below:
 - **A.** Connectors for power cable. Stranded cable conductor connections shall be made using crimp connectors utilizing a crimping tool designed to make a complete crimp before the tool can be removed.
 - **B.** Power cables 600 volt and below. Use heavy-wall self-sealing, heat shrinkable tubing manufactured by Raychem Corporation, Energy Division, Part Number "WCSM", Sigmaform Corporation, Part Number "SST", or approved equal.
 - **C.** Connections to in-pavement light fixtures and isolation transformers shall be by FAA L-824 pre-molded connector. Connectors shall be properly sized according to the power cable diameter.
- **2.10** ELECTRICAL TAPE. Electrical tape shall be Scotch Electrical Tape number Scotch 88 (11/2inch wide) and Scotch 130C linerless rubber splicing tape (2-inch wide), as manufactured by the 3M Company, or approved equivalent.
- **2.11 CABLE IDENTIFICATION TAGS.** Cable identification tags shall be stainless steel with "MALS" stamped or engraved onto the tag. The tags shall be sized as detailed on the drawings.

2.12 CONDUIT

- A. Underground Conduit and Ductbanks. Conduit for underground ductbank shall conform to the requirements of Section L-110 (Underground Conduits for Airports).
- **B.** Above Ground Conduit. Rigid galvanized steel (RGS) conduit and fittings shall be hot dipped galvanized inside and out to conform to the requirements of the Underwriters Laboratories /standard 6, 514B, and 1242.

2.13 CONDUIT INSTALLED BY DIRECTIONAL DRILLING. Not used.

2.14 CONCRETE. Concrete for backfill and encasement shall be P-610. Concrete shall be red when used to encase ducts. Where reinforced duct banks are specified, reinforcing steel shall conform to ASTM A 615 Grade 60. Concrete and reinforcing steel are incidental to the respective pay item of which they are a component part

2.15 LIGHT BASE SEALANTS.

- A. Sealant used around snow plow rings shall conform to the requirements of FAA P-606 Adhesive Compounds, Two-Component for Sealing Wire and Lights in Pavement.
- **B.** Silicone Sealant for base can extensions and shims. Liquid gasket material placed between base cans, extensions, and shims shall be General Electric Co. RTV Silicone Rubber adhesive-sealant, or equal.

2.16 PULL BOXES, HANDHOLES, MANHOLES.

A. Pull boxes must be aircraft rated. Refer to Section L-115 (Electrical Manholes and Junction Structures)

2.17 DISTRIBUTION PANEL

- **A.** The distribution panel is 200-amp, 120/240-volt distribution load center with breakers sized as shown on the drawings. The load center enclosure shall be rated NEMA 4X.
- **B.** Contractor shall provide new circuit breakers as shown on the drawings.
- **2.18 AIR TERMINALS.** The air terminals shall be installed on the mounting frame as shown in the plans as measured by Thompson.

PART 3 - CONSTRUCTION METHODS

3.1 GENERAL. All electrical work shall be installed to meet or exceed the provisions of the current edition of the National Electric Code (NFPA-70), State and local regulations, and applicable portions of these Specifications.

The Contractor shall follow the procedures contained herein and in the drawings in installing the MALSR system equipment.

- **3.2 EXISTING MALSR SYSTEM DEMOLITION.** Existing MALSR system components scheduled for removal are identified on the drawings. Existing MALSR light fixtures shall be salvaged for reinstallation. Unless otherwise specified, removed components, equipment, and materials shall be disposed of by the Contractor off Airport property at a properly licensed facility. Care shall be taken to protect existing equipment, facilities, structures and pavement to remain. All items damaged by the Contractor shall be replaced by the Contractor at the Contractor's own expense.
- **3.3 INSTALLATION TOLERANCES.** Installation of MALSR light bars shall be at the locations specified on the applicable drawings and within the following tolerances:
 - A. Longitudinal displacement (along the runway centerline): +/- 6 inches.
 - **B.** Lateral displacement (perpendicular to the runway centerline): +/- 1 inches.
 - **C.** Distance between individual lights of a light bar: +/- 1 inch.
 - **D.** All lights in a bar shall be installed within +/- 1 inch of a line perpendicular to the runway centerline
 - **E.** All lights shall be aimed parallel to the runway centerline, directed outward from the runway threshold: +/- 5 degrees.

3.4 SUGGESTED INSTALLATION SEQUENCE FOR IN-PAVEMENT LIGHTS

- **A.** In general, MALSR in-pavement light installation work must be closely coordinated with the milling, grading and paving work. Once installed, all equipment shall be protected from damage.
- **B.** Snow plow rings, light units and transformers shall not be installed before final paving is completed.
- **C.** The specifications and drawings detail one method for installation of in-pavement light bases. Alternate installation methods shall be submitted to the Engineer for review and approval. Only alternate installation methods that provide an equal product will be considered for review and approval.

3.5 IN-PAVEMENT LIGHT BASE CAN INSTALLATION IN ASPHALT CONCRETE PAVEMENT

- A. Details for the installation of in-pavement light base cans are shown on the drawings.
- **B.** Following the milling operation or prior to the final asphalt paving, survey the light location.
- **C.** For installation in a milled area, the Contractor shall sawcut the pavement for the light base installation. The existing pavement shall be removed to the depth detailed on the drawings. For installation in a reconstructed asphalt area, excavate the compacted subgrade to the depth detailed on the drawings.
- **D.** Survey light location.

- **E.** Reinforcing bars and the ground rod shall be installed in the pavement removal or excavated area as shown in the drawings.
- **F.** The light base can duct holes shall be fitted with the appropriate rubber grommets, supplied with the base can. Where an unused hole exists due to the geometry of a given location the opening shall be plugged prior to concrete placement. Install temporary overlay protection plate or plywood cover on the base can.
- **G.** The base can shall be supported in place so the top snow plow ring is level and at the elevation and location required to meet the requirements of light unit installation and alignment. Connect the base can to the ground rod with the bare copper wire.
- **H.** Install conduit in the trench and into the base can. Check can position. Proceed with concrete backfill around the base can and conduit. The base can shall be held securely to prevent movement.
- I. Proceed with final asphalt paving.
- **J.** Core drill new asphalt concrete pavement to top of overlay protection plate, remove core, and install extension, snow plow ring and shims.
- **K.** Fill void around extension and shims with P-606 sealant. P-605 sealant shall be used to fill the void above the P-606 material, around the snow plow ring.

3.6 IN-PAVEMENT LIGHT BASE CAN INSTALLATION IN PORTLAND CEMENT CONCRETE PAVEMENT

- A. Details for the installation of in-pavement light base cans are shown on the drawings.
- **B.** Following existing pavement removal, excavation, and compaction of subgrade, survey the light location.
- C. Excavate the base course to install the can, connect to the conduit, and place the concrete foundation.
- **D.** The light base can duct holes shall be fitted with the appropriate rubber grommets, supplied with the base can. Where an unused hole exists due to the geometry of a given location the opening shall be plugged prior to concrete placement.
- **E.** The base shall be supported in place in the excavated area so that the top snow plow ring is level and at the elevation and location required to meet the requirements of light unit installation and alignment. PVC duct sections shall be installed into the can and the reinforcing bar cage shall be installed as required.
- **F.** Check can position. Proceed with concrete backfill around the base; the can shall be held secure to prevent movement.
- **G.** Backfill to the level of the portland cement concrete pavement (PCCP) as shown on the drawings. Concrete backfill shall be worked under any portion of duct, can, and reinforcing cage.
- **H.** Prior to paving the PCCP, install a temporary target plate or plywood cover on the base can. The base can elevation shall be set to allow the installation of the extension, snow plow ring, and shims. At the Contractors option, the extension may be installed following the PCCP placement via a core-drill method. The snow plow ring shall not be used during the paving operation but the Contractor may install temporary shims, furnished at the Contractor's expense, to temporarily build up the base can to the desired elevation. If a cookie-cutter type finish method will be used an approximate 1/2-inch gap shall be provided around the can to allow placement of sealant. The installation and elevation of the base can shall be coordinated

with the paving equipment to ensure the equipment will clear the top of the base can. The Contractor may elect to use either a core or cookie-cutter finish method for finishing around the base can. The finishing method/procedure shall be submitted to the Engineer for review and approval prior to commencing the paving operation.

I. After the PCCP has had time to cure, remove the temporary cover plate, shims, and any other temporary items placed during the paving operation. If a core drill method is used, the core drill shall be sized to create an approximate 1/2-inch gap around the flange ring. Install the extension, snow plow ring and appropriate shims to set the elevation per the specified tolerances. Fill the annular space the sealant as detailed in the drawings.

3.7 INSTALLATION OF FLUSH LIGHT UNITS

- **A.** Remove the temporary base plate and install flange ring and sealant as shown in the drawings and within the tolerances specified.
- **B.** Install the light unit on the snow plow ring following the manufacturer's instructions. Connect the secondary L-823 plug and receptacle without taping the joint. Plug the transformer into the primary circuit, taping joints. Place the transformer in the can. Connect the ground wire from the base can internal lug to the fixture.
- **C.** Bolt the fixture to the base can using the specified hardware. Bolts and washers shall be provided by the Contractor and shall be sufficient length to thread into the base can or extension. Light fixture mounting bolts shall be coated with an anti-seize compound and tightened to 15-foot pounds torque, unless otherwise recommended by the manufacturer.
- **D.** Care shall be taken to keep the flange and gasket clean, attaining a water tight seal.
- **3.8 POWER CABLE INSTALLATION.** Power cable shall be installed in conduit as specified in Section L-108 (Underground Cable for Airport).
- **3.9 CABLE CONNECTIONS.** All MALSR cables shall be continuous (no splices) from the fixtures to the distribution panel and from the distribution panel to the MALSR Shelter.

3.10 GROUNDING INSTALLATION.

- A. All equipment, conduit, and structures shall be grounded as indicated on the drawings. All connection points shall be cleaned of paint, insulation, and other non-conducting materials prior to making the connection. Grounding conductors passing through conduits shall attached to the base cans, junction box ground rod, or end of conduit. Connections shall be made by exothermic connections. Connections to the ground lug inside the base cans may be made by UL labeled and suitable lugs, clamps, or pressure connectors.
- **B.** Light Base Grounding. Each light base shall be individually connected to a separate ground rod.
- **C.** Light Fixture Grounding. Each light fixture or base plate shall be bonded to the light base internal ground lug using a #6 AWG, stranded copper wire rated from 600 volts with green insulation. The ground wire shall be 36-inches long and connected to the base can ground lug by exothermic weld and to the fixture by the supplied mechanical connector.
- **D.** Insulated Ground Wire. The insulated ground wire installed with each circuit shall be connected to the base can internal ground lug in all MALSR base cans, to the ground rod inside pull boxes by exothermic weld, and to the ground bus in the distribution panel by mechanical connector.
- E. Grounding System Inspection and Testing.
 - 1. Continuity of guard wire and ground wire systems shall be checked by visual inspection as construction progresses, prior to work being covered up. Verification of guard wire system

continuity shall also be checked by visual inspection at accessible locations during normal inspections.

- 2. Should the guard wire or ground wire system conductors be damaged or are suspected to be damaged by construction activities (in the opinion of the Engineer) the Contractor shall test the conductors for continuity with a micro-ohmmeter. The conductors shall be isolated such that there is no parallel path. Alternatively, the Contractor may conduct tests and through mathematical computations prove the continuity of the conductors.
- 3. Investigate unsatisfactory results and make necessary corrections or replacements.
- 4. Earth resistance measurements shall be made in normally dry conditions not less than 48 hours after the last rainfall. Maximum resistance readings shall be 10 ohms. If resistance to ground exceeds specified value, provide additional ground rods to bring ground resistance to within tolerance.
- 5. Guard wire and grounding system continuity and resistance test results shall be recorded on an Engineer approved form and submitted to the Engineer immediately following the test procedure.
- **3.11 COUNTERPOISE (GUARD WIRE) INSTALLATION.** Counterpoise wire shall be installed over conduit as shown on the drawings and shall be installed as specified in Section L-110 (Underground Conduit for Airports). Counterpoise size shall be 1/0.
- **3.12 CONDUIT AND DUCTBANK INSTALLATION.** Conduit and ductbank shall be installed where shown on the drawings and shall be installed as specified in Section L-110 (Underground Conduit for Airports).
- **3.13 PULL BOX INSTALLATION.** Pull boxes shall be installed where shown on the drawings and shall be installed as specified in Section L-115 Electrical Manholes & Junction Structures.
- **3.14 DISTRIBUTION PANEL AND EQUIPMENT RACK INSTALLATION.** The distribution panel and equipment rack shall be installed as detailed on drawings.
- **3.15 CABLE TESTING.** All cable testing shall be completed by the Contractor. All test equipment shall have been calibrated within a two-year period preceding the cable testing and shall have current certifications. Test results shall be recorded on an Engineer approved form and submitted to the Engineer immediately following the test procedure. Cable testing shall include at a minimum:
 - A. All circuits are properly connected in accordance with applicable wiring diagrams.
 - **B.** All power circuits shall be continuous and free from short and open circuits.
 - **C.** Resistance Testing: 600-volt cable shall be tested at not less than 500 volts for a minimum of 1-minute and shall measure not less than 100 megohms resistance for each conductor and between conductors.
- **3.16** MALSR SYSTEM TESTING. The Contractor, in the presence of the Engineer, shall perform the general steps outline below in energizing the system. Each step must be verified and approved by the Engineer prior to subsequent step.
 - A. Complete all cable testing as specified.
 - **B.** Measure the voltage at the disconnect switch inside the MALSR Shelter.
 - **C.** With all the circuit breakers in the "open position" in the distribution panel, close the main breaker and measure the voltage at the distribution panel.
 - **D.** Close the individual breakers for each light bar circuit and verify the operation of lighting fixtures. Each light bar shall be first tested individually.

- E. Close all breakers within the distribution panel and verify the operation of all lighting fixtures.
- **F.** In coordination with Airport Operations, the FAA, and the Engineer, the Contractor shall demonstrate operation of the MALSR system for eight (8) continuous hours at the top brightness level and two (2) continuous hours for each lower brightness level.
- **3.17 AS-BUILT SURVEY.** The Contractor will provide two sets of red-line as-built drawings to the Engineer for transmittal to the FAA, for each system, at the conclusion of the project. These are in addition to other documentation as required elsewhere in these Specifications. Contractor shall survey the height and location of each light, all corners of foundation, center of pole or base can at the ground, handhole locations, location of ICC cabinet or junction can, and ductbank run at 100' intervals.

PART 4 - METHOD OF MEASUREMENT

- **4.1 RW 16R MALSR THRESHOLD BAR.** Payment for the new 16R MALSR threshold bar will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing (but not limited to) the following material and equipment to the full satisfaction of the RPR: light fixtures and transformers; base can, extensions, bolts, spacer rings, snow plow ring, anti-seize, ground rod, 600V cable and ground (Size as shown on drawings) rebar and concrete encasement, all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. All components shall be new. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.
- **4.2 RW 16R MALSR STATIONS 2, 4, 6 and 8.** Payment for the new 16R MALSR stations 2, 4, 6 & 8 will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing (but not limited to) the following material and equipment to the full satisfaction of the RPR: includes but not limited to the following: light fixtures and transformers; base can, extensions, bolts, spacer rings, snow plow ring, anti-seize, ground rod, 600V cable and ground (Size as shown on drawings) rebar and concrete encasement, all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. All components shall be new. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.
- **4.3 RW 16R MALSR STATIONS 10.** Payment for the new 16R MALSR station 10 will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing (but not limited to) the following material and equipment to the full satisfaction of the RPR: includes but not limited to the following: light fixtures and transformers; base can, extensions, bolts, spacer rings, snow plow ring, antiseize, ground rod, 600V cable and ground (Size as shown on drawings) rebar and concrete encasement, all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. All components shall be new. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.
- **4.4 RW 16R MALSR STATIONS 12.** Payment for the new 16R MALSR station 12 will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing (but not limited to) the following material and equipment to the full satisfaction of the RPR: includes but not limited to the following: Reinstall existing light fixtures and lamp housings; base can, cover plate, bolts, spacer, anti-seize,

EMT conduit, frangible couplings, ground rod, 600V cable and ground (Size as shown on drawings) rebar and concrete encasement, all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. Reinstall existing light fixtures and lamp housings. All components shall be new unless otherwise noted. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.

- 4.5 RW 16R MALSR STATIONS 14. Payment for the new 16R MALSR station 14 will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing (but not limited to) the following material and equipment to the full satisfaction of the RPR: includes but not limited to the following: reinstallation of light fixture, Airport Furnished LIR MG-20 pole and base plate; base can, cover plate, salvaged frangible bolts, spacer, anti-seize, flex conduit, frangible couplings, ground rod, 600V cable and ground (Size as shown on drawings) rebar and concrete encasement, all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. All components shall be new furnished by Contractor except MG-20 LIR Pole and Base Plate which shall be furnished by Airport. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.
- **4.6 RW 16R MALSR STATIONS 16, 18 & 20.** Payment for the new 16R MALSR station 16, 18 & 20 will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing (but not limited to) the following material and equipment to the full satisfaction of the RPR: includes but not limited to the following: reinstallation of flasher light assembly, ICC cabinet & Junction box; Airport Furnished LIR MG-20 pole and base plate; concrete foundation, base can, cover plate, salvaged frangible bolts, spacer, anti-seize, flex conduit, frangible couplings, ground rod, 600V cable and ground (Size as shown on drawings) rebar and concrete encasement, all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. All components shall be new furnished by Contractor except MG-20 LIR Pole and Base Plate which shall be furnished by Airport. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.
- **4.7 RW 16R MALSR STATIONS 22.** Payment for the new 16R MALSR station 22 will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing (but not limited to) the following material and equipment to the full satisfaction of the RPR: includes but not limited to the following: reinstallation of flasher light assembly; Airport Furnished LIR MG-20 pole; anti-seize, flex conduit, frangible couplings, ground rod, 600V cable and ground (Size as shown on drawings), all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. All components shall be new furnished by Contractor except MG-20 LIR Pole and Base Plate which shall be furnished by Airport. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.
- **4.8 RW 16R MALSR STATIONS 24.** Payment for the new 16R MALSR station 24 will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing (but not limited to) the following material and equipment to the full satisfaction of the RPR: includes but not limited to the following: reinstallation of flasher light assembly; Airport Furnished LIR MG-30 pole and assembly; antiseize, flex conduit, frangible couplings, ground rod, 600V cable and ground (Size as shown on drawings), all required connections, sealant; and all other incidentals, materials, and labor required

to complete the installation as described in contract plan details. All components shall be new furnished by Contractor except for MG-20 and assembly which shall be furnished by Airport. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.

- **4.9 RW 34L MALSR THRESHOLD BAR.** Payment for the new 34L MALSR threshold bar will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing the material and equipment to the full satisfaction of the RPR including but not limited to the following: base can, extensions, bolts, spacer rings, snow plow ring, transformers, anti-seize, ground rod, 600V cable and ground (Size as shown on drawings) rebar and concrete encasement, all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. Existing light fixtures shall be reinstalled and bulbs replaced if required. All components shall be new except for the lights which shall be reinstalled. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.
- **4.10 RW 34L MALSR STATIONS 2, 4, 6, 8, 10 and 12.** Payment for the new 34L MALSR stations 2, 4, 6, 8, 10 & 12 will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing the material and equipment to the full satisfaction of the RPR including but not limited to the following: base can, extensions, bolts, spacer rings, snow plow ring, transformers, anti-seize, ground rod, 600V cable and ground (Size as shown on drawings) rebar and concrete encasement, all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. Existing light fixtures shall be reinstalled and bulbs replaced if required. All components shall be new except for the lights which shall be reinstalled. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.
- **4.11 RW 34L MALSR STATIONS 14.** Payment for the new 34L MALSR station 14 will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing the material and equipment to the full satisfaction of the RPR including but not limited to the following: Reinstall existing light fixtures and lamp housings; base can(s), cover plate, bolts, spacer, anti-seize, EMT conduit, frangible couplings, ground rod, 600V cable and ground (Size as shown on drawings) rebar and concrete encasement, all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. Reinstall existing light fixtures and lamp housings. All components shall be new except for lights which shall be reinstalled. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.
- **4.12 RW 34L MALSR STATIONS 16, 18 & 20.** Payment for the new 34L MALSR station 16, 18 & 20 will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing the material and equipment to the full satisfaction of the RPR including but not limited to the following: reinstallation of flasher light assembly, ICC cabinet & above-ground Junction box; Airport Furnished LIR MG-20 pole and base plate; concrete foundation, base can, cover plate, salvaged frangible bolts, spacer, anti-seize, flex conduit, frangible couplings, ground rod, 600V cable and ground (Size as shown on drawings) rebar and concrete encasement, all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. All components shall be new except for the MG-20 LIR Pole and Base Plate which shall be furnished by the Airport and for the flasher assembly, ICC cabinet, and above-ground junction which shall be reinstalled. Bid item includes all materials and

equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.

- **4.13 RW 34L MALSR STATIONS 22 & 24.** Payment for the new 34L MALSR station 22 & 24 will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing (but not limited to) the following material and equipment to the full satisfaction of the RPR: includes but not limited to the following: reinstallation of flasher light assembly; Airport Furnished LIR MG-20 pole; antiseize, flex conduit, frangible couplings, ground rod, 600V cable and ground (Size as shown on drawings), all required connections, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. All components shall be new except for the MG-20 LIR Pole and Base Plate which shall be furnished by the Airport and for the flasher assembly which shall be reinstalled. Bid item includes all materials and equipment between the MALSR lights to the nearest handhole including conduits, base can, and all associated equipment.
- **4.14 MALSR 16R WIRING, DISTRIBUTION UNIT (DU) CABINET, AND ASSOCIATED CONNECTIONS.** Payment for the new 16R wiring, DU cabinet, and associated connections will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing (but not limited to) the following material and equipment to the full satisfaction of the RPR: Nema 4X distribution panel & Junctions box, stainless steel Unistrut, anti-seize, EMT & RGS conduit, frangible couplings, ground rod, all wiring cable, and ground wire throughout the entire 16R system including power and communication (Sizes as shown on drawings), all required connections, testing, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. All components shall be new unless otherwise noted. Bid item includes all cable between the MALSR shelter to each MALSR light station and all associated equipment. Note; length of wire may change in the field to accommodate field conditions; Contractor shall include an additional 20% length of cable/wire for each type of cable/wire of cable for the MALSR system and this length is included in in the lump sum bid item.
- **4.15 MALSR 34L WIRING, DU CABINET, AND ASSOCIATED CONNECTIONS.** Payment for the new 16R wiring, DU cabinet, and associated connections will be paid for at the contract unit price per lump sum, complete in place, ready for operation, and accepted by the RPR. The price for this bid item includes furnishing and installing (but not limited to) the following material and equipment to the full satisfaction of the RPR: Nema 4X distribution panel & Junctions box, stainless steel Unistrut, anti-seize, EMT & RGS conduit, frangible couplings, ground rod, all wiring cable, and ground wire throughout the entire 16R system including power and communication (Sizes as shown on drawings), all required connections, testing, sealant; and all other incidentals, materials, and labor required to complete the installation as described in contract plan details. All components shall be new unless otherwise noted. Bid item includes all cable between the MALSR shelter to each MALSR light station and all associated equipment. Note; length of wire may change in the field to accommodate field conditions; Contractor shall include an additional 20% length of cable/wire for each type of cable/wire of cable for the MALSR system and this length is included in in the lump sum bid item.
- **4.16 MALSR MISCELLANEOUS WORK (BOTH ENDS).** Payment for MALSR Miscellaneous Work (Both Ends) will be paid for at the contract unit price per lump sum, for all material, equipment and labor not paid for under other bid items. This includes but not limited to demolition, testing, coordination with FAA, assist the FAA in performing contractor acceptance inspection (minimum 2 electricians for 4 days), assist the airport in performing flightcheck, as-built, survey of light locations, and all other work and materials not specifically paid for in other bid items.

PART 5 - BASIS OF PAYMENT

Payment will be made under:

Item No.	Description	Unit
L-146-1	RW 16R MALSR Threshold Bar	Lump Sum
L-146-2	RW 16R MALSR Station 2, 4, 6 and 8	Lump Sum
L-146-3	RW 16R MALSR Station 10	Lump Sum
L-146-4	RW 16R MALSR Station 12	Lump Sum
L-146-5	RW 16R MALSR Station 14	Lump Sum
L-146-6	RW 16R MALSR Station 16,18 and 20	Lump Sum
L-146-7	RW 16R MALSR Station 22	Lump Sum
L-146-8	RW 16R MALSR Station 24	Lump Sum
L-146-9	RW 34L MALSR Threshold Bar	Lump Sum
L-146-10	RW 34L MALSR Station 2, 4, 6, 8, 10 and 12	Lump Sum
L-146-11	RW 34L MALSR Station 14	Lump Sum
L-146-12	RW 34L MALSR Station 16, 18 & 20	Lump Sum
L-146-13	RW 34L MALSR Station 22 and 24	Lump Sum
L-146-14	MALSR 16R Wiring, DU Cabinet, and Associated Connections	Lump Sum
L-146-15	MALSR 34L Wiring, DU Cabinet, and Associated Connections	Lump Sum
L-146-16	MALSR Miscellaneous Work (Both Ends)	Lump Sum

-----END OF SECTION------

SECTION L-150 INSTALLATION OF LED PRECISION APPROACH PATH INDICATOR

GENERAL

150-1.1 SUMMARY. This Section includes the requirements for furnishing and installing the Precision Approach Path Indicators, including all wire and cable connections, all necessary conduits and fittings, and all necessary mounting structures. As shown on the Plans and as necessary to complete the work.

150-1.2 DESCRIPTION. This item shall consist of furnishing and installing the Precision Approach Path Indicator (PAPI) in accordance with these specifications.

This item shall also include all wire and cable connections, the furnishing and installing of all necessary conduits and fittings and all necessary mounting structures. It shall also include the testing of the installation and all incidentals necessary to place the PAPI lights in operation as completed units to the satisfaction of the Construction Manager

150-1.3 RELATED SECTIONS.

- a. Section L-100, Airfield Electrical General Requirements
- **b.** Section L-108, Underground Power Cable for Airports
- c. L-110, Airport Underground Electrical Duct Banks and Conduits

150-1.4 REFERENCES. The following references are incorporated into the requirements of the Work as described in this Section. For other references that apply to all electrical Work, refer to Section L-100, *Airfield Electrical General Requirements*.

PRODUCTS

150-2.1 PAPI. The PAPI shall conform to the requirements of FAA Advisory Circular 150/ 5345-28 (latest revision), "Precision Approach Path Indicator Systems." PAPI shall be LED.

EQUIPMENT SUPPLIED. The system shall consist of the following classification:

- a. <u>Type.</u> L-880 System consisting of 4 light units
- **b.** <u>Style.</u> Style B Airfield series circuit powered
- c. <u>Class.</u> Class I Operation down to -35° C

The system shall also include Interconnection Field Splice Kits, one Aiming Device and one Instruction Manual. The manufacturer shall also have a downloadable electronic version of the manual available on their web site.

150-2.3 PAPI LIGHT UNIT. Each Light Unit shall include LED lamps. Lamps and filters will be easily replaceable without need of re-calibration. The Light Unit shall be made from folded aluminum sheet fully protected against corrosion. The Light Unit shall be fully weatherproof. A hardened glass shall be provided in front of the lenses to protect against sandblast.

The average intensity in red light will be at least 15,000 Cd for a horizontal beam spread of -6° to $+6^{\circ}$ and a vertical angle of 3.5° below transition. The transition sector will not exceed 3 minutes of arc over the full beam width.

To minimize spare parts requirements, there shall be no difference between a FAA Style A Light Unit and a Style B Light Unit. Each Light Unit shall include a tilt switch with associated electronics. The Light Unit electronics shall generate an indication showing which Light Unit has tilted.

The Light Unit shall be constructed as follows:

a. <u>Legs.</u> Three legs per Light Unit, for ease of alignment <u>Lamps.</u> Two lamps per Light Unit is preferred although three lights units are acceptable.

150-2.4 STYLE B SYSTEM REQUIREMENTS. The Light Units shall be powered via the airfield series circuit. Each 2-lamp Light Unit shall require no more than one 500W isolation transformer.

150-2.5 PAPIS SHALL BE CERTIFIED IN ACCORDANCE WITH FAA AC 150/5340-53 AT THE TIME WHEN CONTRACTOR IS PROVIDED NOTICE TO PROCEED.

EXECUTION

150-3.1 PLACING THE PAPI LIGHTS. The contractor shall furnish and install the PAPI system as specified in the proposal and shown in the plans. The PAPI shall be mounted on a concrete base at the location shown on the plans. The PAPI shall be vertically aligned according to the requirements in the plans using the aiming device provided by the manufacturer. The tilt switch shall be leveled on all PAPI light units according to the manufacturer's instructions.

150-3.2 TESTS. The system shall be fully tested by continuous operation for not less than 24 hours as a completed system prior to acceptance. The test shall include the functioning of each intensity control in both Remote and Local not less than 10 times at the beginning and end of the 24-hour test. Submit a testing and installation plan by the manufacturer for commissioning the PAPI systems.

150-3.3 FLIGHTCHECK. Contractor shall furnish an alignment tool for the PAPI and shall be on-hand during the flightcheck to make quick, remedial corrections. Assume 2 electricians with knowledge and capability to make corrections for a period of no less than 3 each 12 hour shifts to perform this work. Flightcheck will take place both at night and daytime.

METHOD OF MEASUREMENT

150-4.1 RUNWAY 16R LED PAPI AND FOUNDATION._The quantity to be paid for the LED PAPI shall be measured per Lump Sum installed in place by the Contractor and accepted by the Construction Manager. This bid item shall include but not be limited to the following items: all 4 PAPI light housing assemblies, lamps, foundation, connectors, conduit and wire between PAPI assemblies and conduit, aiming tool, grounding, base can, testing, assistance during flightcheck, and commissioning and

all other appurtenances required to complete the installation. This bid item covers all of the materials and equipment from the nearest handhole or junction can to the first base can and PAPI assembly to the fourth base can and PAPI assembly inclusive of all grounding, conduit, and cable. Bid item also includes support and assistance for flightcheck and alignment tool.

150-4.2 RUNWAY 34L LED PAPI AND FOUNDATION. The quantity to be paid for the LED PAPI shall be measured per Lump Sum installed in place by the Contractor and accepted by the Construction Manager. This bid item shall include but not be limited to the following items: all 4 PAPI light housing assemblies, lamps, foundation, connectors, conduit and wire between PAPI assemblies and conduit, aiming tool, grounding, base can, testing, assistance during flightcheck, and commissioning and all other appurtenances required to complete the installation. This bid item covers all of the materials and equipment from the nearest handhole or junction can to the first base can and PAPI assembly to the fourth base can and PAPI assembly inclusive of all grounding, conduit, and cable. Bid item also includes support and assistance for flightcheck and alignment tool.

BASIS OF PAYMENT

150-5.1 PAYMENT. Payment will be made at the contract unit price for each completed PAPI system installed and accepted by the Construction Manager. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete this item.

Payment will be made under:

Bid Item	Description	<u>Unit</u>
L-150-1	Runway 16R LED PAPI and Foundation.	Lump Sum
L-150-2	Runway 34L LED PAPI and Foundation.	Lump Sum

END OF SECTION L-150

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ITEM 13410A AIRFIELD LIGHTING CONTROL AND MONITORING SYSTEM MODIFICATIONS (WORK PERFORMED BY MANUFACTURER)

DESCRIPTION

13410A-1.1 PROJECT SCOPE.

This specification details the scope for the manufacturer of the ALCS, ADB-Safegate:

- Fully functional and complete ALCMS
- Providing Field Service Personnel as needed to complete system, coordinate with and provide direction to Contractor, and maintain project schedule
- Software and programming upgrades to include the updated taxiway geometry modifications
- ALCMS screens, maps, and data base updates
- System Commissioning
- System Calibration
- On-site training (Maintenance and Air Traffic Control)
- System manuals and documentation
- Coordinate and perform final inspection
- Acceptance tests

a. The work shall include all supervision, labor, software, programming, materials, tools, equipment, testing of the installation, manual updates, and all incidentals necessary to provide a fully functional and complete system to the satisfaction of the Construction Manager.

b. Maintain a fully functional and operational airport lighting control system throughout the modification and testing of the affected system components. Coordinate construction with the Construction Manager to avoid conflicts with airport operational requirements and to schedule required system outages.

c. Provide a 1-year maintenance warranty agreement which shall include the furnishing of key spare parts along with technical support on a 24 hour/ 7 day week/ 365 day year both remote and on site.

13410A-1.2 SUBMITTAL.

a. Equipment and software submittals shall meet the requirements listed in Item L-100, Lighting and Electrical Work. The Supplier shall submit the complete dimensional and performance characteristics, system block diagram, wiring schematic diagrams and installation and operation instructions. The block diagram shall reflect the total integration of all new digital and analog devices into the existing system. The diagram shall reference all interconnection cabling requirements for digital components of the system including any data communications links.

b. All significant equipment to be supplied shall be listed, followed by descriptive data sheets. The equipment list shall include each component name, supplier, model number, a description of the operation, quantity supplied and any special setup, operation and maintenance characteristics.

c. Software submittals shall provide a complete description of the system on a functional level.

d. Submittals of graphic displays shall include color pictorial representations of all runway and taxiway operations above 1200' RVR, between 1200' and 600' RVR including SMGCS operations affected by this project.

13410A-1.3 OPERATION AND MAINTENANCE MANUALS. The supplier shall provide revision pages for eight existing operation and maintenance manuals. The manual revisions shall be easy-to-understand and contain detailed instructions and well-diagrammed procedures for operations and systems maintenance.

13410A-1.4 WARRANTY. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of twenty-four (24) months or the manufacturer's standard guarantee period whichever is greater, from final acceptance by the Construction Manager. Any defective materials and/or equipment shall be repaired or replaced, at the Construction Manager's discretion, with no additional cost to the Owner.

13410A-1.5 TESTING.

a. General:

1. All elements of the ALCMS system affected by work associated with this project shall be tested to demonstrate that the total system satisfies all of the functional requirements of this Specification.

- 2. As a minimum, the testing shall include the following:
 - (a) Software Implementation Tests (SIT).
 - (b) Operational Acceptance Tests (OAT).
 - (c) Functional Acceptance Tests (FAT).

3. Each test shall be in the cause and effect format. The person conducting the test shall initiate an input (cause) and, upon the systems or subsystems producing the correct result (effect), the specific test requirement will have been satisfied.

4. All tests shall be conducted in accordance with, and documented on, prior Owner-approved procedures, forms, and checklists. Each specific test to be performed shall be

described and a space provided after it for signoff by the appropriate party after its satisfactory completion.

5. Copies of these signoff test procedures, forms, and checklists will constitute the required test documentation.

6. Provide all special testing materials and equipment. Perform tests using actual system variables, equipment, and data.

7. Coordinate all testing with the Owner.

8. The Owner will actively participate in many of the tests. The Owner reserves the right to test or retest any and all specified functions whether or not explicitly stated in the prior-approved Test Procedures.

9. The Owner's decision shall be final regarding the acceptability and completeness of all testing.

b. Software Implementation Tests (SIT):

1. The new software shall be installed on one of the existing ALCMS for testing and to demonstrate that the proposed system components will function through the reconfigured software.

2. Tests shall demonstrate all newly installed or reinstalled hardware and software components function to the satisfaction of the Owner. As a minimum the tests shall include the following from AC 150/5345-56, Specification for L-890 Airport Lighting Control and Monitoring System (ALCMS), latest edition:

- (a) 10.6.1 Communication Link Test
- (b) 10.6.3 Tower Remote Control Test
- (c) 10.6.4 Requesting and Granting Control
- (d) 10.6.5 Preset Failsafe System Test
- (e) 10.9.3 Initiating a Low Visibility Test
- (f) Operational state of the remote Circuit Selector Switch test.

c. Operational Acceptance Tests (OAT):

1. At the completion of the SIT, the system shall be made available to the Owner's personnel for hands-on operational testing. The system shall be completely usable and available for the OAT.

2. The OAT will run for a period of 2 days. Coordinate all tests and provide assistance for any simulations needed with the Owner. The supplier shall be on site for the duration of the tests. The OAT shall be performed for both the primary and secondary ALCMS.

3. At the end of the OAT, the Owner, and Contractor shall coordinate and address any discrepancies found during the OAT.

4. All discrepancies shall be taken care of prior to the start of the FAT.

d. Functional Acceptance Tests (FAT):

1. Once the system has completed the OAT, a witnessed Functional Acceptance Test shall be performed on the complete ALCMS to demonstrate that it is operating and in compliance with these Specifications. Each specified function shall be demonstrated on a paragraphby-paragraph and site-by-site basis.

2. Updated versions of the documentation shall be made available to the Owner at the jobsite both before and during the tests. In addition, one copy of an O&M Manual shall be made available to the Owner at the jobsite both before and during testing.

3. The daily schedule called for under paragraph SIT shall also be followed during the FAT.

13410A-1.6 ONSITE SERVICES.

a. General:

1. Provide experienced personnel and management onsite to coordinate and effect, for modifications to the Airfield Lighting Control and Monitoring System:

- (a) Installation, termination, and adjustment.
- (b) All onsite testing.
- (c) Startup assistance.
- **b.** Onsite Supervision:

1. Provide onsite, an experienced resident engineering manager to supervise and coordinate all of the onsite Airfield Lighting Control and Monitoring System activities. This resident engineering manager shall be onsite during the total period required to effect all of the required onsite activities relating to the Airfield Lighting Control and Monitoring System modification.

- **c.** Attend planning meetings (2 of them) as required.
- **d.** Testing Team:

1. Provide, onsite, a team of experienced engineering and technician personnel during the total period required to:

(a) Thoroughly check the installation, termination, and adjustment of all of the Subsystems and their components affected by this project.

(b) Perform and complete all onsite tests.

(c) Provide assistance to the Owner for a period of one calendar week after interim and final acceptance inspections.

13410A-1.7 PROJECT CONDITIONS.

a. This project is located on an active airport and work is subject to security and other restrictions.

b. The airport will be operational during construction and requires coordination and prior approval from the resident engineer for any planned power and systems outages. All work inside the airport security fence shall be coordinated with the Construction Manager.

c. The existing airport lighting control system shall remain operational during construction and testing of the system modifications. The existing control system configuration shall remain operational until the Construction Manager accepts the new system modifications.

13410A-1.8 HARDWARE FOR PROCUREMENT.

a. Any modifications or additional hardware required to make a fully functional system.

CONSTRUCTION REQUIREMENTS

a. In the event that a communication or software adjustment or defective equipment requires repair or replacement, testing may be suspended or continued at the sole discretion of the Construction Manager. Prior tests shall be verified to still meet the project requirements before continuing if testing is suspended.

b. If the need for further adjustments of any kind becomes evident during inspection or demonstration, the supplier shall continue work until the installation operates properly.

METHOD OF MEASUREMENT

13410A-3.1 ALCMS modification shall be measured for payment as lump sum for providing services, material and coordinating installation of ALCMS computer software to reflect changes associated with this project, testing, coordination, site support, as-built, and all other appurtenances and accessories required for a fully functional system in place, ready for operation and accepted by the RPR as described in drawings. This bid item shall include all taxes, overhead, and profit associated with the manufacturer's work but does not cover any of the Contractor's cost. Bid Item L-128-3 covers all of the contractor's cost including management, escort, taxes, and profit and this bid item shall only cover the manufacturer's cost. Note; this bid item covers all work for all bid alternates regardless of which one or all chosen.

BASIS OF PAYMENT

13410-4.1 Payment will be made under bid items for the following:

13410A-1 ALCS Modifications Lump Sum

END OF ITEM 13410A

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