PROJECT MANUAL

2017 ANNUAL AIRFIELD PAVEMENT REHABILITATION

CONTRACT NO. 201733182

VOLUME II
TECHNICAL SPECIFICATIONS

ISSUED FOR 90%

March 15, 2017

CITY & COUNTY OF DENVER
DEPARTMENT OF AVIATION
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END OF SECTION
ITEM P-150 DEMOLITION

DESCRIPTION

150-1.1 This item shall consist of removal of existing concrete slabs on grade, foundations, sheds and building foundations, fences, water wells, asphalt pavement, concrete pavement, corrugated metal and reinforced concrete pipe, existing headwalls and wingwalls, guardrail, drainage items, pavement markings, electrical items, and any other items within the Project Limits. The Contractor shall dispose of the material at a licensed disposal site or as directed by the DEN Project Manager. Material salvaged shall become the property of the Contractor.

The Contractor shall notify all utility, oil, and gas facility owners and the DEN Project Manager in writing 30 days in advance of requiring work in areas currently occupied by oil and gas wells and buried pipelines.

150-1.2 BURIED PIPELINES. Contractor is responsible to contact the owner as to the status of the pipeline. If pipelines have been abandoned in-place by the pipeline owners, the pipelines may not have been purged or cleaned and may contain petroleum products. The contractor shall exercise extreme care in removing these facilities and is responsible for removing the pipe including any remaining contents, irrespective of the current pipe conditions. The Contractor should also expect to find other pipelines, etc. which have been abandoned by unknown owners during the 15 to 20-year life of the oil and gas fields.
Contract documents indicate the general location of known pipelines and developed utilities. All pipelines shown on the drawings shall be located by Contractor by potholing to verify location, depth, and usage. The Contractor shall remove all utility pipes and lines included in the earthwork contract area in accordance with these specifications. All buried pipelines, utilities, buried tanks, and any other structures within the construction area of all runways, taxiways and aprons extending to 10 feet (3 m) outside the limits of construction and not less than 15 feet (4.6 m) below the finished grade level shall be removed. The Contractor shall notify oil and gas facility owners and the DEN Project Manager in writing 30 days in advance of requiring work in areas currently occupied by oil and gas wells and buried pipelines.

Piping a minimum of 15 feet (4.6 m) below finished grade elevations or plan excavation may be left in place or removed and salvaged at the discretion of the Contractor. The ends of any pipelines left in place shall have the ends capped prior to burial, according to applicable Federal Department of Transportation Regulations. Any piping which is left in place shall be surveyed and the coordinates of the ends of the abandoned pipe (or other items left in place) shall be provided to the DEN Project Manager and included on the "as-built" drawings.
150-1.3 ELECTRICAL. The Contractor shall remove all abandoned cable, cable identified to be removed, ductwork, base cans including concrete encasement and all light fixtures, signs and duct markers within the construction limits of taxiway and runway pavements to be removed, widened or constructed, or as shown on the Drawings. Protect existing airfield lighting fixtures and base plates from damage and deliver them to the Airport for storage as directed by the DEN Project Manager. Discard all base cans, conduit, transformers and cable off-site. The Electrical Contractor shall provide written documentation to the DEN Project Manager that electrical cable has been removed prior to slab sawcutting and demolition.

150-1.4 FOUNDATIONS AND SLABS ON GRADE. All structures at or above grade and to a depth of not less than 15 feet (4.6 m) below the final finished grade line and within 10 feet horizontally of the construction limits shall be removed.

150-1.5 WATER WELLS. There is a possibility that water wells are located in work areas. The wells are permitted by the State of Colorado and shall be abandoned in accordance with current Revised and Amended Rules and Regulations of the Board of Examiners of Water Well Construction and Pump Installation Contractors.

150-1.6 REMOVAL OF PAVEMENT MARKINGS OR CURING COMPOUND. All paint or concrete curing compound to be removed, as shown on the plans shall be removed from the surface of the existing pavement. Equipment, tools and machines used in the performance of the removal operation shall be safe and in satisfactory working condition at all times. The Contractor shall provide satisfactory evidence that the Contractor’s equipment has been used in the performance of similar work. On asphalt pavements, water blasting will be allowed only if it can be demonstrated that no major damage to the asphalt pavement occurs, otherwise, grinding will be required. Major damage is defined as changing the properties of the pavement or removing pavement over 1/8 inch (3 mm) deep. On concrete pavements, water blasting shall be used for all removals.

The water blasting equipment shall be truck mounted and shall be capable of water pressures of 2,000 to 40,000 psi (14 to 276 MPa). The equipment shall be capable of adjusting the pressure to accomplish paint or cure removal without damaging the paving surface. The equipment shall be capable of following a straight line and be maneuverable to accommodate various pavement markings. The spray width needs to be able to accommodate lines 6” and wider. If water blasting is used to remove lines on active airfield pavements, a vacuum system will be provided to allow for timely repainting and the prevention of any debris being ingested into propellers or turbine engines once the water blasting equipment has exited the active pavements.

If required on asphalt pavement, the grinding equipment shall be capable of adjusting the height to accomplish paint removal with only lightly scarifying, but not damaging the paving surface. The equipment shall be capable of following a straight line and be maneuverable to accommodate various pavement markings. A vacuum truck shall be used to immediately clean up all debris created by the removal process.
No material shall be deposited on the airfield pavement. All wastes shall be disposed of in areas indicated in this specification or shown on the plans.

150-1.7 EXISTING ROADWAYS. Roadway demolition shall consist of all portions of asphalt and concrete roadway within the project limits, including all existing haul roads and any alternate access road.

150-1.8 REMOVAL OF GUARDRAIL. Guardrail removal shall consist of the removal and disposal of the existing guardrail, cable road guard and guardrail posts.

150-1.9 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR. All operations shall be carefully controlled to prevent damage to the concrete pavement and to the underlying material to remain in place. All saw cuts shall be made perpendicular to the slab surface.

a. Removal of Existing Pavement Slab. When it is necessary to remove existing concrete pavement and leave adjacent concrete in place the joint between the removal area and adjoining pavement to stay in place shall first be cut full depth with a standard diamond-type concrete saw. Next, a full depth saw cut shall be made parallel to the joint at least 24 inches (610 mm) from the joint and at least 12 inches (305 mm) from the end of any dowels. All pavements between this last saw cut and the joint line shall be carefully broken up and removed using hand-held jackhammers, 30 lb. (14 kg) or less, or the approved light-duty equipment which will not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. The joint face shall be sawed or otherwise trimmed so that there is no abrupt offset in any direction greater than 1/2-inch (13 mm) and no gradual offset greater than 1 inch (25 mm) when tested in a horizontal direction with a 12 ft. (3.7 m) straightedge. Sawcutting depth may vary nominally and no extra payment will be allotted for varying depths.

The Contractor shall remove the remaining portion of concrete pavement slab by lifting and placing directly into haul trucks. The Contractor will not be allowed to use hydraulic rams on excavators that may damage the cement treated base below the pavement to be removed.

An alternative removal method may be accepted by the DEN Project Manager if the Contractor can demonstrate to the DEN Project Manager successful removal without damage to adjacent concrete or base material below. If during subsequent removals it is found the method is causing damage to the adjacent panels or base material below, the Contractor’s method shall be rejected by the DEN Project Manager and the DEN Project Manager shall direct the Contractor to begin using the method above.

The Contractor’s removal operation shall not cause damage to cables, utility ducts, pipelines, or drainage structures under the pavement. Concrete slabs that are damaged by under breaking shall be removed. Any damage shall be repaired at the Contractor’s expense.

b. Edge Repair. The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Areas which are damaged
during construction shall be repaired at no cost to the Owner; repair of previously existing
damage areas will be paid for as listed in the bid schedule.

(1) Spall Repair. Spalls shall be repaired where indicated and where
directed. Repair materials and procedures shall be completed as required in specification P-
501.

(2) Underbreak Repair. Any under breaking of slabs that are to remain
in-place shall result in the entire slab removal and replacement at the Contractor’s expense to
the next joint.

(3) Underlying Material. The underlying material adjacent to the edge
of and under the existing pavement which is to remain in place shall be protected from
damage or disturbance during removal operations and until placement of new concrete, and
shall be shaped as shown on the drawings or as directed. Sufficient material shall be kept in
place outside the joint line to prevent disturbance (or sloughing) of material under the
pavement which is to remain in place. Any material under the portion of the concrete
pavement to remain in place which is disturbed or loses its compaction, shall be carefully
removed and replaced with concrete. The underlying material outside the joint line shall be
thoroughly compacted and moist when new concrete is placed. If the disturbed material
causes under breaking of concrete panels that are to remain in-place, it shall result in the
entire slab removal and replacement at the Contractor’s expense to the next joint.

150-1.10 EXISTING ASPHALT CONCRETE PAVEMENT REMOVAL AND
REPAIR BY MILLING. This item shall consist of milling existing bituminous concrete
pavement to allow for placement of sufficient thickness of bituminous concrete overlay for
pavement repairs or construction on the runway or taxiway shoulders.

The vertical edges of the milled surface shall be sawcut to expose a clean true vertical edge
to pave against.

All operations shall be carefully controlled to prevent damage to the asphalt pavement and to
the underlying material to remain in place.

Stairstep milling is required for the runway and taxiway shoulder widening interface. This
item shall consist of multiple passes as required to establish the “stairstep”, as shown on the
plans.

150-1.11 EXISTING FULL DEPTH ASPHALT CONCRETE PAVEMENT
REMOVAL. This item shall consist of sawcutting and removal of existing bituminous
concrete pavement (including Asphalt Treated Permeable Base (ATPB)) to allow for
replacement of P-501 slabs along the edges adjacent to asphalt shoulders. A standard
diamond-type concrete saw shall be used to make the sawcut the full depth of the asphalt
pavement (including ATPB). The pavement shall be removed so the joint for each layer of
pavement replacement is offset 1 foot (305 mm) from the joint in the preceding layer. This
does not apply if the removed pavement is to be replaced with concrete or soil.
The edge of existing bituminous concrete pavement against which new pavement abuts shall be protected from damage at all times. Areas which are damaged during construction shall be repaired at no cost to the Owner.

All operations shall be carefully controlled to prevent damage to the asphalt pavement and to the underlying material to remain in place.

150-1.12 REMOVAL OF SIGNS AND DELINEATORS. Sign demolition shall consist of the removal and disposal of the all existing signs and delineators, including their foundations and posts, within the project limits along all existing haul roads and any alternate access road.

150-1.13 WASTE DISPOSAL. All removed asphalt and concrete pavements shall be delivered to the recycle yard in accordance with Section 01 74 19 Construction Waste Management. All other demolished materials shall be considered waste and disposed offsite at facilities approved for waste materials, unless specified otherwise.

MATERIALS

150-2.1 BURIED PIPELINE. Materials used to cap off pipelines remaining in the ground shall be of the size and type normally used for this operation.

150-2.2 EQUIPMENT. Excavation and Hauling Equipment: Provide equipment as necessary to remove underground pipelines and other demolished items.

CONSTRUCTION METHODS

150-3.1 GENERAL. Blasting will not be allowed on this project.

150-3.2 BURIED PIPELINE AND STORM SEWERS.

a. Trenching. The removal of cover on top of and surrounding the abandoned pipelines shall be performed without damaging the pipeline. All trench sidewalls shall be properly sloped or benched and/or braced, shored or sheeted to afford safe working conditions, to protect adjacent pipelines, and to prevent caving.

b. Testing. The Contractor shall test the exposed trench excavation and the pipeline for dangerous or explosive gases and to positively determine that the line has been emptied, cleaned and/or purged prior to performing any further operations.

c. Cutting of Pipeline and Storm Sewers. Extreme care shall be exercised whenever the pipeline or storm sewer to be removed is cut into, especially the first cut on the abandoned pipeline. The Contractor shall use a method to cut the pipeline into sections for removal which provides safety for workers and equipment. The initial cut shall not be made with a cutting torch.

(1) BACKFILLING. If required, select embankment (1” maximum size), per Technical Specification P-152 Excavation and Embankment, or P-153 Controlled Low-
Strength Material, to 12 inches (305 mm) over the top of the pipe shall be completed before backfilling operations are started.

The Contractor shall take all necessary precautions to protect the pipe from any damage, movement or shifting. In general, backfilling shall be performed by pushing the material from the end of the trench into, along and directly over the pipe so that the material will be applied in the form of a rolling slope rather than by side filling which may damage the pipe. Backfilling from the sides of the trench will be permitted after sufficient material has first been carefully placed over the pipe to such a depth as to protect the pipe.

Compaction equipment used above the pipe zone shall be of a type that does not damage the pipe. Provide for the proper maintenance of traffic flow and accessibility as may be necessary. Make adequate provisions for the safety of property and persons. Temporary cribbing, sheeting, or other timbering shall be removed unless specifically authorized in writing. Dewatering shall be continued until the trench is completely backfilled. Brush, stumps, logs, planking, disconnected drains, boulders, etc., shall be removed from the material to be used for backfilling the trench.

(2) GENERAL COMPACTION REQUIREMENTS. Requirements of this section shall apply unless more stringent requirements are established by the local agency involved.

Trench backfill shall be compacted to the requirements of Item P-152.

(3) MECHANICAL COMPACTION. Method of compaction shall be at Contractor's option.

The Contractor shall be responsible to provide the proper size and type of compaction equipment and select the proper method of utilizing said equipment to attain the required compaction density. In-place compaction tests shall be made. Contractor shall remove and re-compact material that does not meet specified requirements.

d. Removal of water and residual petroleum products from pipelines. Any pipeline containing water or residual petroleum products after abandonment by the pipeline owner shall have the water or the residual products removed from the pipeline, by the Contractor, using a nitrogen purge, steam, or other approved means. The material removed from the pipeline shall be hauled away and disposed of properly. The Contractor shall assume that all pipelines to be removed contain significant amounts of residual products that must be disposed of offsite.

150-3.3 BURIED UTILITY LINES. The Contractor shall remove all abandoned electrical and telephone lines whether shown on the contract drawings or not. All known lines are shown, but there may be other unknown abandoned lines in the area. It shall be the Contractor's responsibility to check the status of all abandoned lines. Care shall be taken to assure that all abandoned electric lines are not live and cannot be activated accidentally.
150-3.4 GROUND SURFACE REPAIR. The Contractor shall rough grade and compact areas affected by demolition to maintain site grades and contours. All holes remaining after demolition operations shall have sides broken down to flatten out the slopes, and shall be filled with acceptable material, moistened and properly compacted in layers to the density required in Item P-152, Excavation and Embankment. The ground surface area repaired shall properly drain and that water will not pond.

150-3.5 WATER WELLS. The Contractor shall employ a licensed water well contractor to demolish and abandon existing water wells and provide necessary documentation to the State of Colorado Agencies and Boards as required.

150-3.6 INSPECTION POINTS. Upon completion of demolition work and prior to backfilling operations, the DEN Project Manager shall inspect the Contractor's work. After backfilling and grading operations, the Contractor's Quality Control Inspector shall perform inspection and final acceptance, per Division 1 General Requirements Section 01 45 10 – Contractor Quality Control and Section 01 45 20 Contractor Quality Control Program - FAA.

150-3.7 MILLING. The construction operation shall be scheduled and proceed in a manner that produces a uniformly finished milled surface with a neat uniform right angle cut at the end of the milled section. The depth of the Asphalt Pavement Removal shall be as called for on the plans and/or full depth of the joining lift. The entire area designated on the plans shall be milled until the pavement surfaces result in pavement that conforms to the typical section and cross section requirements specified. The milling process shall produce a pavement surface that is true to grade with a uniform texture. The transverse slope of the pavement shall be uniform to a degree that no depressions or misalignment of slope greater than 1/2-inch in 16 feet are present when tested with a straightedge.

Milling shall be performed with a power-operated milling machine or grinder, capable of producing a finished surface that provides a good bond to the new overlay. The milling machine or grinder shall operate without tearing or gouging the under laying surface. The milling machine or grinder shall be equipped with automatic grade and slope controls. All millings shall be removed and disposed of in an approved waste site. If the Contractor mills or grinds deeper or wider than the plans specify, the Contractor shall replace the material that was removed with new material at no additional cost to the Owner.

The Contractor shall establish positive means for removal of milled residue. Solid residue shall be removed from pavement surfaces before it is blown by traffic action or wind. Residue shall not be permitted to flow into drainage facilities. The milled residue shall be disposed of legally off airport property. The millings generated shall be disposed of off-site.

METHOD OF MEASUREMENT

150-4.1 REMOVE CONCRETE PAVEMENT – 17” REINFORCED. Measurement for payment of Removal of 17-inch reinforced concrete pavement shall be made per square yard based on the area shown on the plans. Any pavement removed outside the designed limits of removal because the pavement was damaged by negligence on the part of the Contractor shall not be included in the measurement for payment. The thickness of the
existing material to be removed is approximate only and the Contractor will not be reimbursed for areas that may be thicker than shown on the plans. Removal of pavement shall include all sawcutting, excavation, hauling, and disposal (including disposal fees) of pavement necessary to facilitate removal.

150-4.2 REMOVE CONCRETE PAVEMENT – 17” NON-REINFORCED. Measurement for payment of Removal of 17-inch non-reinforced concrete pavement shall be made per square yard based on the area shown on the plans. Any pavement removed outside the designed limits of removal because the pavement was damaged by negligence on the part of the Contractor shall not be included in the measurement for payment. The thickness of the existing material to be removed is approximate only and the Contractor will not be reimbursed for areas that may be thicker than shown on the plans. Removal of pavement shall include all sawcutting, excavation, hauling, and disposal (including disposal fees) of pavement necessary to facilitate removal.

150-4.3 REMOVE BITUMINOUS SHOULDER PAVEMENT – FULL DEPTH. Measurement for payment of Removal of bituminous shoulder pavement full depth shall be made per square yard based on the area shown on the plans. Any pavement removed outside the designated limits of removal because the pavement was damaged by negligence on the part of the Contractor shall not be included in the measurement for payment. The thickness of the existing material to be removed is approximate only and the Contractor will not be reimbursed for areas that may be thicker than shown on the plans. Removal of pavement shall include all sawcutting, excavation, hauling and disposal (including disposal fees) of pavement necessary to facilitate removal.

150-4.4 REMOVE BITUMINOUS SHOULDER PAVEMENT – 3” DEPTH BY COLD MILLING. Measurement for payment of Removal of bituminous shoulder pavement 3 inch depth by cold milling shall be made per square yard based on the area shown on the plans. Any pavement removed outside the preapproved limits of removal because the pavement was damaged by negligence on the part of the Contractor shall not be included in the measurement for payment. Removal of pavement shall include all sawcutting, hauling and disposal (including disposal fees) of pavement necessary to facilitate removal.

150-4.5 DEMOLISH L-868 BASE CAN. Measurement for payment of Demolish L-868 Base Can shall be made per each. The removal of lights includes base can, concrete anchor, rebar, and conduit. The fixture shall be salvaged to a location on DEN property as directed by the DEN Project Manager. The isolation transformer, base can, spacer rings, and concrete shall be disposed of off-site.

BASIS OF PAYMENT

150-5.1 REMOVE CONCRETE PAVEMENT – 17” REINFORCED. Payment shall be made at the contract unit price per square yard of pavement material removed and disposal of removed material off-site. This price shall be full compensation for furnishing all materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.
150-5.2 **REMOVE CONCRETE PAVEMENT – 17” NON-REINFORCED.**
Payment shall be made at the contract unit price per square yard of pavement material removed and disposal of removed material off-site. This price shall be full compensation for furnishing all materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

150-5.3 **REMOVE BITUMINOUS SHOULDERS PAVEMENT – FULL DEPTH.**
Payment shall be made at the contract unit price per square yard for pavement material removed and disposal of removed material off-site. This price shall be full compensation for furnishing all materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

150-5.4 **REMOVE BITUMINOUS SHOULDERS PAVEMENT – 3” DEPTH BY COLD MILLING.** Payment shall be made at the contract unit price per square yard for pavement material removed and disposal of removed material off-site. This price shall be full compensation for furnishing all materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

150-5.5 **DEMOLISH L-868 BASE CAN.** Payment shall be made at the contract unit price per each base can removed. The price includes the removal of, base can, concrete anchor, rebar, and conduit and delivery of removed existing fixture to DEN. This price shall be full compensation for furnishing all materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

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**END OF ITEM P-150**
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. Unclassified Excavation. Unclassified excavation shall consist of the excavation and disposal of all material, regardless of its nature, which is not otherwise classified and paid for under one of the following items.

   b. [Rock Excavation. Rock excavation shall include all solid rock in ledges, in bedded deposits, in un-stratified masses, and conglomerate deposits which are so firmly cemented they cannot be removed without blasting or using rippers. All boulders containing a volume of more than 1/2 cubic yard (0.4 cubic meter) will be classified as “rock excavation.”]

   c. Muck Excavation. Muck excavation shall consist of the removal and disposal of deposits or mixtures of soils and organic matter not suitable for foundation material. Muck shall include materials that will decay or produce subsidence in the embankment. It may consist of decaying stumps, roots, logs, humus, or other material not satisfactory for incorporation in the embankment.

   d. Drainage Excavation. Drainage excavation shall consist of all excavation made for the primary purpose of drainage and includes drainage ditches, such as intercepting, inlet or outlet; ditches; temporary levee construction; or any other type as shown on the plans.

   e. Borrow Excavation. Borrow excavation shall consist of approved material required for the construction of embankments or for other portions of the work in excess of the quantity of usable material available from required excavations. Borrow material shall be obtained from areas designated by the DEN Project Manager within the limits of the airport property but outside the normal limits of necessary grading, or from areas outside the airport.]
152-1.3 **UNsuitable excavation.** Any material containing vegetable or organic matter, such as muck, peat, organic silt, or sod shall be considered unsuitable for use in embankment construction. Material, suitable for topsoil may be used on the embankment slope when approved by the DEN Project Manager.

152-1.4 **select embankment.** Select Embankment shall consist of material as described below.

There are 2 zones of Select Embankment Material:

- Lower Select Embankment: the lower 4.5 feet (1.4 m)
- Upper Select Embankment: the upper 1.5 feet (.5 m).
- The upper 8 inches (200 mm) to 1 foot (300 mm) of the Upper Select Embankment will be cement treated.

Lower Select Embankment material shall consist of existing in-place select fill, including moisture conditioning of the existing on-site select fill. Moisture conditioning of the existing select fill shall be performed to a depth of 5 feet (1.5 m) below planned finished grades or to 3 feet (1 m) below existing site grades, whichever is greater. This will require over-excavation of existing soils using a maximum 8 inch (200 mm) lift thickness, and tested for classification (including gradation and Atterberg limits), swell-consolidation, and water soluble sulfates will not be required for Lower Select Embankment material consisting of in-place and moisture conditioned existing on-site select fill.

If required, imported Lower Select Embankment materials be free of unsuitable materials, including claystone, contain 100% passing the 3 inch (75 mm) sieve, less than 90% passing the No. 200 sieve, have a maximum Liquid Limit of 40, a maximum Plasticity Index of 30, and less than 3% swell potential. The swell sample shall be remolded to 95% of the maximum dry density at optimum moisture as determined by ASTM D 698 for initial acceptance of the proposed imported Lower Select Embankment Material. During placement of the imported Lower Select Embankment Material, the swell sample shall be obtained from the compacted in-place imported Lower Select Embankment Material.

The lower and upper select embankment materials should be properly moisture conditioned and compacted in accordance with the specifications.

Upper Select embankment material shall be obtained from the borrow area indicated in the plans and shall meet the requirements of the specification.

- **Cement Treated Upper Select Embankment.** The Upper Select Embankment material, of which the upper 8 inches (200 mm) to 1 foot (300 mm) will be cement-treated, shall be an imported material free of unsuitable materials, with 100% passing the 1-inch sieve, no more than 45% retained on a No. 4 sieve, less than 50% passing the No. 200 sieve, a maximum Plasticity Index of 15, a maximum water soluble sulfates content of...
1.5%, and less than 3% swell potential. The swell sample shall be remolded to 95% of the maximum dry density at optimum moisture as determined by ASTM D 698 for initial acceptance of the proposed Upper Select Embankment material. During placement of the Upper Select Embankment material, the swell sample shall be obtained from the compacted in-place Upper Select Embankment material.

152-1.5 MATERIAL CLASSIFICATION. Non-cohesive soils, for the purposes of determining compaction control, are those with a plasticity index of less than 3 when tested in accordance with ASTM D 4318. Any other material shall be considered cohesive.

CONSTRUCTION METHODS

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

The suitability of material to be placed in embankments shall be subject to approval by the DEN Project Manager. All unsuitable material shall be disposed of in waste areas shown on the plans. All waste areas shall be graded to allow positive drainage of the area and of adjacent areas. The surface elevation of waste areas shall not extend above the surface elevation of adjacent usable areas of the airport, unless specified on the plans or approved by the DEN Project Manager.

When the Contractor’s excavating operations encounter artifacts of historical or archaeological significance, the operations shall be temporarily discontinued and the DEN Project Manager notified. At the direction of the DEN Project 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.

Those areas outside of the limits of the pavement areas where the top layer of soil material 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.

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 DEN Project Manager, who shall arrange for their removal if necessary. The Contractor, at his or her 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.

152-2.2 EXCAVATION. No excavation shall be started until the work has been staked out by the Contractor and the DEN Project Manager has obtained from the Contractor, the survey notes of the elevations and measurements of the ground surface. All areas to be excavated shall be stripped of vegetation and topsoil. Topsoil shall be stockpiled for future use in areas designated on the plans or by the DEN Project Manager. All suitable excavated
material shall be used in the formation of embankment, subgrade, or other purposes shown on the plans. All unsuitable material shall be disposed of as shown on the plans.

When the volume of the excavation exceeds that required to construct the embankments to the grades indicated, the excess shall be used to grade the areas of ultimate development or disposed as directed by the DEN Project Manager. When the volume of excavation is not sufficient for constructing the embankments to the grades indicated, the deficiency shall be obtained from borrow areas.

The grade shall be maintained so that the surface is well drained at all times. When necessary, temporary drains and drainage ditches shall be installed to intercept or divert surface water that may affect the work.

a. **Selective Grading.** When selective grading is indicated on the plans, the more suitable material designated by the DEN Project 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 so that it can be measured for payment as specified in paragraph 152-3.3.

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 DEN Project Manager. 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 locations shown on the plans] [disposed off the airport. The cost is incidental to this item]. This excavated material shall be paid for at the contract unit price per cubic yard (per cubic meter) for [ ]. The excavated area shall be backfilled with suitable material obtained from the grading operations or borrow areas and compacted to specified densities. The necessary backfill will constitute a part of the embankment. Where rock cuts are made, backfill with select material. Any pockets created in the rock surface shall be drained in accordance with the details shown on the plans.

c. **Overbreak.** Overbreak, including slides, is that portion of any material displaced or loosened beyond the finished work as planned or authorized by the DEN Project Manager. All overbreak shall be graded or removed by the Contractor and disposed of as directed by the DEN Project Manager. The DEN Project Manager shall determine if the displacement of such material was unavoidable and his or her decision shall be final. Payment will not be made for the removal and disposal of overbreak that the DEN Project Manager determines as avoidable. Unavoidable overbreak will be classified as “Unclassified Excavation.”

d. **Hazardous Materials.** Some material (equipment, debris, soil, wastes, etc.) may be affected by hazardous constituents, chemicals or compounds used during oil and gas production, residential development, public improvement construction or agricultural use. Material contaminated or potentially contaminated with hazardous constituents, chemicals or compounds shall be assessed by the contractor regarding the hazardous characteristic(s) of
each material. The assessment will be made in accordance with requirements specified by the Colorado Department of Public Health and Environment (CDPHE) and the Colorado Department of Natural Resources - Oil and Gas Conservation Commission (OGCC). The Contractor shall notify the Engineer in writing immediately upon discovery or suspicion of the existence of such hazardous material.

e. **Removal of Utilities.** The removal of existing structures and utilities required to permit the orderly progress of work will be accomplished by someone other than the Contractor; for example, the utility unless otherwise shown 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 DEN Project Manager. All foundations thus excavated shall be backfilled with suitable material and compacted as specified.

f. **Compaction Requirements.** The subgrade under areas to be paved shall be compacted to a depth of [ ] and to a density of not less than [ ] percent of the maximum density as determined by ASTM [ ]. The material to be compacted shall be within +/- 2% of optimum moisture content before being rolled to obtain the prescribed compaction (except for expansive soils).

The in-place field density shall be determined in accordance with [ASTM D 1556] [ASTM D 2167] [ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated in accordance with ASTM D 6938]. 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. The finished grading operations, conforming to the typical cross-section, shall be completed and maintained at least 1,000 feet (300 m) ahead of the paving operations or as directed by the DEN Project Manager.

All testing shall be done by a laboratory hired by the Contractor. The results shall be furnished daily to the Engineer for determination of acceptance.

In areas of excavation, a minimum of two density and moisture content tests shall be taken per day or a minimum of one test per [ ] square yards, whichever results in a greater number of tests. Density and moisture content tests are only required on the final surface. If field-tested density or moisture content of the final surface is found to be outside of a specified range, the area represented by the test shall be re-worked and re-tested. Pavement materials shall not be placed on the completed surface until testing results have been furnished to, and approved in writing by the Engineer.

All loose or protruding rocks on the back slopes of cuts shall be pried loose or otherwise removed to the slope finished grade line. 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 DEN Project Manager.

[Blasting shall not be allowed.] [Blasting will be permitted as directed by the DEN Project Manager and in accordance with the following:]
Blasting will be permitted only when proper precautions are taken for the safety of all persons, the work, and the property. All damage done to the work or property shall be repaired by the Contractor. The cost of repair is incidental to this item. All operations of the Contractor in connection with the transportation, storage, and use of explosives shall conform to all federal, state and local regulations and explosive manufacturers’ instructions, with applicable approved permits reviewed by the DEN Project Manager. Any approval will not relieve the Contractor of his or her responsibility in blasting operations.

Where blasting is approved, the Contractor shall employ a vibration consultant, approved by the DEN Project Manager, to advise on explosive charge weights per delay and to analyze records from seismograph recordings. The seismograph shall be capable of producing a permanent record of the three components of the motion in terms of particle velocity, and in addition shall be capable of internal dynamic calibration.

In each distinct blasting area, where pertinent factors affecting blast vibrations and their effects in the area remain the same, the Contractor shall submit a blasting plan of the initial blasts to the DEN Project Manager for approval. This plan must consist of hole size, depth, spacing, burden, type of explosives, type of delay sequence, maximum amount of explosive on any one delay period, depth of rock, and depth of overburden if any. The maximum explosive charge weights per delay included in the plan shall not be increased without the approval of the DEN Project Manager.

The Contractor shall keep a record of each blast: its date, time and location; the amount of explosives used, maximum explosive charge weight per delay period, and, where necessary, seismograph records identified by instrument number and location.

g. These records shall be made available to the DEN Project Manager on a monthly basis or in tabulated form at other times as required.

Proof Rolling. 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 (0.551MPa/0.689 MPa/1.034 MPa)] [20 ton Proof Roller with tires spaced not more than 32 inches (0.8 m) on-center with tires inflated to 100/125/150 psi (0.689 MPa/0.861 MPa/1.034 MPa)] [heavy pneumatic-tired roller having four or more tires abreast, each tire loaded to a minimum of 30,000 pounds (13.6 metric tons) and inflated to a minimum of 125 psi (0.861 MPa)] in the presence of the DEN Project Manager. Apply a minimum of [ ] coverage, or as specified by the DEN Project Manager, to all paved 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.

152.2 3  BORROW EXCAVATION. Borrow areas within the airport property are indicated on the plans. Borrow excavation shall be made only at these designated locations and within the horizontal and vertical limits as staked or as directed.
The contractor shall distinguish borrow sources to distinguish materials to be used as common embankment and select embankment. The Contractor shall prepare a Select Embankment Material Plan for select material excavation and select material placement based on the plan information and the Contractor’s further exploration of upper select embankment material availability. The Select Embankment Material Plan shall contain the results of the following investigation:

a. Select Borrow investigation for designated areas.

b. Test hole or pit explorations in runway/taxiway and select borrow areas at approximately 300' on centers.

c. Sample testing at each exploration for depth of topsoil, depth of select material, elevation of surface, and laboratory tests for Plasticity Index, sieve analysis, percent passing 200 sieve, classification, soluble sulfates, and swell consolidation.

d. Detailed log of each test hole or pit.

e. Estimate of select material available in each area.

When borrow sources are outside the boundaries of the airport property, it shall be the Contractor’s responsibility to locate and obtain the borrow source, subject to the approval of the DEN Project Manager. The Contractor shall notify the DEN Project Manager at least 15 days prior to beginning the excavation so necessary measurements and tests can be made. All borrow pits shall be opened up to expose the various strata of acceptable material to allow obtaining a uniform product. All unsuitable material shall be disposed of by the Contractor. Borrow pits shall be excavated to regular lines to permit accurate measurements, and they shall be drained and left in a neat, presentable condition with all slopes dressed uniformly.

152-2.4 DRAINAGE EXCAVATION. Drainage excavation shall consist of excavating for drainage ditches such as intercepting; inlet or outlet ditches; for temporary levee construction; or for any other type as designed or as shown on the plans. The work shall be performed in sequence with the other construction. Intercepting ditches shall be constructed prior to starting adjacent excavation operations. All satisfactory material shall be placed in embankment fills; unsuitable material shall be placed in designated waste areas or as directed by the DEN Project Manager. All necessary work shall be performed true to final line, elevation, and cross-section. The Contractor shall maintain ditches constructed on the project to the required cross-section and shall keep them free of debris or obstructions until the project is accepted.

152-2.5 PREPARATION OF EMBANKMENT AREA. Where an embankment is to be constructed to a height of 4 feet (1.2 m) or less, 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 as indicated in paragraph 152-2.6. When the height of fill is greater
than 4 feet (1.2 m), sod not required to be removed shall be thoroughly disked and recompacted to the density of the surrounding ground before construction of embankment.

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.

152-2.6 FORMATION OF EMBANKMENTS. Embankments shall be formed in successive horizontal layers of not more than 8 inches (200 mm) in loose depth for the full width of the cross-section, unless otherwise approved by the DEN Project Manager.

The layers shall be placed, to produce a soil structure as shown on the typical cross-section or as directed by the DEN Project 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 because of 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 layer shall be within 0% to -2% of optimum moisture content before rolling to obtain the prescribed compaction. To achieve a uniform moisture content throughout the layer, the material shall be moistened or aerated as necessary. Samples of all embankment materials for testing, both before and after placement and compaction, will be taken for each [ ]. Based on these tests, the Contractor shall make the necessary corrections and adjustments in methods, materials or moisture content to achieve the specified embankment density.

Rolling operations shall be continued until the embankment is compacted to not less than 95% of maximum density for noncohesive soils, and 90% of maximum density for cohesive soils as determined by ASTM [ ]. Under all areas to be paved, the embankments shall be compacted to a depth of [ ] and to a density of not less than [ ] percent of the maximum density as determined by ASTM [ ].

On all areas outside of the pavement areas, no compaction will be required on the top 4 in (100 mm).
The in-place field density shall be determined in accordance with [ASTM D1556] [ASTM D2167] [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]. The [DEN Project Manager shall perform all density tests] [Contractor’s laboratory shall perform all density tests in the DEN Project Manager’s presence and provide the test results upon completion to the DEN Project Manager for acceptance].

In embankment areas, a minimum of two density and moisture content tests shall be taken per lift per day or a minimum of one test per [ ] cubic yards of material placed, whichever results in a greater number of tests. If field-tested density or moisture content of a completed lift is found to be outside of a specified range, the area represented by the test shall be re-worked and re-tested. Additional embankment or pavement materials shall not be placed on the completed lift or area until testing results have been furnished to, and approved in writing by the DEN Project Manager.

Compaction areas shall be kept separate, and no layer shall be covered by another layer 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 layer is placed. Layer placement shall begin in the deepest portion of the embankment fill. As placement progresses, the layers shall be constructed approximately parallel to the finished pavement grade line.

When rock and other embankment material are excavated at approximately the same time, the rock shall be incorporated into the outer portion of the embankment and the other material shall be incorporated under the future paved areas. Stones or fragmentary rock larger than 4 inches (100 mm) in their greatest dimensions will not be allowed in the top 6 inches (150 mm) of the subgrade. Rockfill shall be brought up in layers as specified or as directed by the DEN Project Manager and the finer material shall be used to fill the voids with forming a dense, compact mass. Rock or boulders shall not be disposed of outside the excavation or embankment areas, except at places and in the manner designated on the plans or by the DEN Project Manager.

When the excavated material consists predominantly of rock fragments of such size that the material cannot be placed in layers of the prescribed thickness without crushing, pulverizing or further breaking down the pieces, such material may be placed in the embankment as directed in layers not exceeding 2 feet (60 cm) in thickness. Each layer shall be leveled and smoothed with suitable equipment by distribution of spalls and finer fragments of rock. The layer 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 layers, 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.] [Payment for compacted
embankment will be made under embankment in-place and no payment will be made for excavation, borrow, or other items.]

152-2.7 FINISHING AND PROTECTION OF SUBGRADE. After the subgrade is substantially complete, the Contractor shall remove any soft or other unstable material over the full width of the subgrade that will not compact properly. All low areas, holes or depressions in the subgrade shall be brought to grade with suitable select material. 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.

Grading of the subgrade shall be performed so that it will drain readily. The Contractor shall protect the subgrade from damage and limit hauling over the finished subgrade to only traffic essential for construction purposes. All ruts or rough places that develop in the completed subgrade shall be graded and recompacted.

No subbase, base, or surface course shall be placed on the subgrade until the subgrade has been approved by the DEN Project Manager.

152-2.8 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.

152-2.9 TOLERANCES. In those areas upon which a subbase or base course is to be placed, the top of the subgrade shall be of such smoothness that, when tested with a 12-foot (3.7-m) straightedge applied parallel and at right angles to the centerline, it shall not show any deviation in excess of 1/2 inch (12 mm), and shall not be more than 0.05 feet (15 mm) from true grade as established by grade hubs. The smoothness measurements shall be made by the Contractor on a 50-foot grid parallel and perpendicular to the centerline in the presence of the DEN Project Manager. The grade shall be determined at spot elevations shown on the Plans for the surface course, on a grid not to exceed 50 feet. Any deviation in excess of these amounts shall be corrected by loosening, adding, or removing materials; reshaping; and recompacting.

On safety areas, intermediate and other designated areas, the surface shall be of such smoothness that it will not vary more than 0.10 feet (3 mm) from true grade as shown on the typical sections and/or contours shown on the plans and meeting FAA grading criteria. Any deviation in excess of this amount shall be corrected by loosening, adding or removing materials, and reshaping.

152-2.10 TOPSOIL. When topsoil is specified or required as shown on the plans or under Item T-905, it shall be salvaged from stripping or other grading operations. The topsoil shall meet the requirements of Item T-905. If, at the time of excavation or stripping, the topsoil cannot be placed in its final section of finished construction, the material shall be stockpiled at approved locations. Stockpiles shall not be placed within [ ] feet of runway pavement or [ ] feet of taxiway pavement and shall not be placed on areas that subsequently
will require any excavation or embankment fill. If, in the judgment of the DEN Project Manager, it is practical to place the salvaged topsoil at the time of excavation or stripping, the material shall be placed in its final position without stockpiling or further rehandling.

Upon completion of grading operations, stockpiled topsoil shall be handled and placed as directed, or as required in Item T-905.

152-2.11 RESTORING BORROW AREAS. The Contractor shall, upon completion of his borrow excavation activities, prepare the borrow sites for planting by performing the following work:

a. Remove and bury all rock over 6" in dimension in accordance with rock disposal methods as noted under Section 3.02 Excavation P-152.

b. Grade all sites to drain as indicated in these specifications and drawings.

c. Remove all trash and other foreign objects so that the areas can be reused for farming purposes.

d. Rip the borrow area site in a manner as approved by the DEN Project Manager. After the area is ripped to the 18 inch (450 mm) depth, the area ripped shall be treated on the surface to reduce excessive surface roughness or cloddiness and produce an area suitable for future seeding. Treatment may include discing, harrowing, cultipacking or other means as approved by the Engineer. In areas where rock is the predominant surface remaining, the Contractor may spread 18 inches (450 mm) of acceptable material over the rock areas as approved by the Engineer at no additional cost to the City.

All work required to prepare the borrow area for planting as designated under this section shall be considered as incidental work.

METHOD OF MEASUREMENT

152-3.1 The quantity of excavation to be paid for shall be the number of cubic yards (cubic meters) measured in its original position.

Measurement shall not include the quantity of materials excavated without authorization beyond normal slope lines, or the quantity of material used for purposes other than those directed. [The quantity of compacted embankment in-place to be paid for shall be the number of cubic yards (cubic meters) measured in its final position.]

152-3.2 Borrow material shall be paid for on the basis of the number of cubic yards (cubic meters) measured in its original position at the borrow pit.

152-3.3 Stockpiled material shall be paid for on the basis of the number of cubic yards (cubic meters) measured in the stockpiled position.
152-3.4 For payment specified by the cubic yard (cubic meter), measurement for all [excavation] [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] [embankment] cross sections shown on the plans, subject to verification by the Engineer. After completion of all [excavation] [embankment] operations and prior to the placing of base or subbase material, the final [excavation] [embankment] shall be verified by the Engineer by means of field cross sections taken randomly at intervals not exceeding 500 linear feet (150 meters).

152-3.5 [The quantity of embankment in place shall be the number of cubic yards measured in its final position.]

BASIS OF PAYMENT

152-5.1 [“Unclassified excavation” payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.]

152-5.2 [“Rock Excavation” payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.]

152-5.3 [“Muck Excavation” payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.]

152-5.4 [“Drainage Excavation” payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.]

152-5.5 [“Borrow Excavation” payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.]

152-5.6 [“Stockpiled Material” payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.]

152-5.7 [“Embankment in Place” payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.]

Payment will be made under:
[Item P-152-4.1] Unclassified Excavation—per cubic yard (cubic meter)]

[Item P-152-4.2] Rock Excavation-per cubic yard (cubic meter)]

[Item P-152-4.3] Muck Excavation-per cubic yard (cubic meter)]

[Item P-152-4.4] Drainage Excavation-per cubic yard (cubic meter)]

[Item P-152-4.5] Borrow Excavation-per cubic yard (cubic meter)]

[Item P-152-4.6] Stockpiled material-per cubic yard (cubic meter)]

[Item P-152-4.7] Embankment in Place-per cubic yard (cubic meter)]

TESTING REQUIREMENTS

ASTM D698 Test for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures, Using 5.5-pound (2.49 kg) Rammer and 12 in (305 mm) Drop

ASTM D1556 Test for Density of Soil In Place by the Sand-Cone Method

ASTM D1557 Test for Laboratory Compaction Characteristics of Soil Using Modified Effort

ASTM D2167 Test for Density and Unit Weight of Soil In Place by the Rubber Balloon Method.

ASTM D6938 In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods

END OF ITEM P-152
ITEM P-160 WATERING

DESCRIPTION

160-1.1  This work shall consist of obtaining, conveying, and applying water for compaction of embankments and subgrades; for concrete; haul road; for dust control; and for any other purposes in accordance with the requirements of the Contract Documents or as designated by the DEN Project Manager.

MATERIALS

160-2.1  WATER QUALITY. Water required for construction use shall be clean and free from sewage, oil, acid, strong alkalis, organic material, and other substances injurious to the finished product. Water obtained from the City supplied source is acceptable for use as construction water. If the Contractor provides an alternative source for water supply, water of questionable quality shall be tested in accordance with ASTM C1602. All alternative supply sources shall be subject to approval by the DEN Project Manager.

160-2.2  CITY SUPPLIED WATER SOURCE. The City shall make available a source of construction water from the water line close to the existing Contractor Staging Area location shown on the Drawings. There is not an unlimited supply of water available and the Contractor will be held responsible for misuse of water. The tap size shall be limited to 1-1/2 inches (38 mm).

It shall be the Contractor's responsibility to contact the Denver Water Department (DWD) and the DEN Project Manager and arrange for connection to the above referenced waterline, to include installation of meter. The Contractor's connection plan, its distribution system, and its filling operations must be coordinated with, submitted to, and approved by the DWD prior to installation. All costs associated with waterline connections and distribution shall be included in the unit prices bid for the applicable items of construction.

160-2.3  POTABLE WATER. Potable water may be hauled in and stored by the Contractor.

CONSTRUCTION METHODS

160-4.1  TRANSPORT OF WATER. The Contractor may transport water overland to an approved temporary storage facility, or construct temporary supply piping to his primary use point. The approximate location and alignment of the Contractor's temporary supply/distribution system must be approved by the DEN Project Manager in writing prior to its installation and must be removed by the Contractor upon completion of work. Potential
contamination of existing domestic water system shall be held as the responsibility of the contractor.

160-4.2  EQUIPMENT. The water equipment shall be of capacity and designed to assure uniform application of water in the amounts required.

160-4.3  PERMITS. The Contractor shall obtain the required DWD permit(s) relative to tapping the water line and/or the use of said water.

METHOD OF MEASUREMENT

160-5.1  There shall be no direct measurement or payment for watering. The work under this item shall be considered subsidiary to other items of work.

BASIS OF PAYMENT

160-6.1  Watering shall be considered incidental to the project. No payment shall be made for watering.

TESTING REQUIREMENTS

ASTM C1602  Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

END OF ITEM P-160
ITEM P-161 GEOTEXTILE

DESCRIPTION

161-1.1 This item shall consist of the work necessary to furnish and install geotextile fabrics on base course and asphalt pavement, complete.

161-1.2 QUALITY ASSURANCE CERTIFICATION. Contractors shall furnish geotextile fabric materials and shall submit to the DEN Project Manager a mill certificate or affidavit signed by a legally authorized official from the company manufacturing the fabric. The mill certificate or affidavit shall attest that the fabric meets chemical, physical, and manufacturing requirements stated in this Specification. Contractors shall also submit to the DEN Project Manager, not later than 45 days prior to commencing work in this section, documented evidence of proven technical competence, past record of satisfactory performance on similar projects, and sufficient capacity to do the volume of work specified herein.

161-1.3 SUBMITTALS. All contractors shall furnish to the DEN Project Manager, no later than 45 days prior to delivery of materials to the project, the following data:

a. Complete material specifications, descriptive drawings, and literature.

b. Listing of all exceptions to the requirements specified herein.

c. Factory test results of materials certified by fabric manufacturer being similar shall be submitted showing conformance with the requirements of these Specifications and which by actual usage has been demonstrated to be satisfactory for the intended application.

Before commencing the work specified under this section, the Contractor shall submit to the DEN Project Manager for approval all installation drawings, procedures, and a schedule for carrying out the work.

Contractors shall submit certification from manufacturer that the product delivered to the project site will have property values equal to or greater than those specified. Certified property values shall be equal to the average value less 2 standard deviations.

A sample of 1 square foot of the geotextile fabric shall be furnished to the DEN Project Manager from each shipment for verification and testing. The lot number of the roll and the location of the sample obtained must be documented.

Samples of fabric sewn scams and/or securing pins shall also be furnished if required on the project.
161-1.4 MANUFACTURER’S SERVICES. A fabric manufacturer's representative shall inspect the site for acceptability and provide technical supervision and assistance at all times during installation of the fabric, and as may be required by the DEN Project Manager.

MATERIALS

161-2.1 NON-WOVEN GEOTEXTILE FABRIC. The non-woven geotextile fabric shall be used for areas beneath the shoulder section of Item P-404 and placed as a bond breaker over Item P-304 and P-306 for PCC pavement sections. For filter fabric installed as a component part of the underdrain system, refer to the requirements in Item D-705. Fabric material shall be a pervious sheet of polyester, polypropylene, polyethylene, or polyamide fibers oriented into a stable network so that the fibers retain their relative position with respect to each other. The fabric shall be composed of continuous or discontinuous (staple) fibers held together through spun bonding, melt bonding, resin bonding, or needle punching. The edges of the fabric shall be salvaged or otherwise finished to prevent the other material from pulling away from the fabric. The fabric shall be woven into a width greater than 6 feet. The fabric shall conform to the physical requirements in Table No. 1.

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<th>Physical Requirements</th>
<th>Test Method</th>
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<tr>
<td>Thickness, MU., min</td>
<td>70</td>
</tr>
<tr>
<td>Mass (Weight), oz./sq.yd. (g/sq. meter), min.</td>
<td>6.0 (203)</td>
</tr>
<tr>
<td>Water Permittivity sec. min.</td>
<td>1.5</td>
</tr>
<tr>
<td>Apparent Opening Six (AOS), U.S. Standard Sieve Size</td>
<td>50</td>
</tr>
<tr>
<td>Grab Tensile Strength, lbs. (kg), min.</td>
<td>180 (81)</td>
</tr>
<tr>
<td>Grab Elongation, % min.</td>
<td>50</td>
</tr>
<tr>
<td>Mullen Burst Strength, psi (kPa), min.</td>
<td>290 (7)</td>
</tr>
<tr>
<td>Puncture Strength, lbs. (kg), min.</td>
<td>80 (36)</td>
</tr>
<tr>
<td>Trapezoid Tear Strength, lbs.(kg), min.</td>
<td>75 (34)</td>
</tr>
<tr>
<td>Seam Efficiency, %</td>
<td>70-90</td>
</tr>
<tr>
<td>Hydrocarbon Resistance, % Change</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Ultraviolet Radiation Resistance, % Strength Retention, min. at 150 hours</td>
<td>70</td>
</tr>
</tbody>
</table>
161-2.2 STRESS-ABSORBING FABRIC (PAVEMENT REINFORCEMENT GRID). The fabric shall be specifically developed for the reinforcement of asphalt overlays. The paving grid shall be heat and fatigue resistant, have high strength and low elongation. The material shall be manufactured of glass yarns, knitted into a stable interlocking grid and coated with a polymer-modified bitumen adhesive to improve bonding within the pavement construction. The grid shall meet the properties shown in Table 2 and have the following minimum average roll properties:

**TABLE 2. PAVEMENT REINFORCEMENT GRID PROPERTIES**

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Minimum Value</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>oz/SY (g/SM)</td>
<td>16 543</td>
<td>ASTM D 5261-92</td>
</tr>
<tr>
<td>Aperture Size (Grid Size) (Typical)</td>
<td>Inch (mm)</td>
<td>¾ 19</td>
<td>N/A</td>
</tr>
<tr>
<td>Transverse Direction</td>
<td>Inch (mm)</td>
<td>1 25</td>
<td>N/A</td>
</tr>
<tr>
<td>Wide Width Tensile Strength @ Ultimate</td>
<td>lb./inch (N/mm)</td>
<td>560 98</td>
<td>ASTM D 6637</td>
</tr>
<tr>
<td>Transverse Direction</td>
<td>lb./inch (N/mm)</td>
<td>1120 196</td>
<td>ASTM D 6637</td>
</tr>
<tr>
<td>Elongation at Break</td>
<td>Percent</td>
<td>3 max.</td>
<td>ASTM D 6637</td>
</tr>
<tr>
<td>Transverse Direction</td>
<td>Percent</td>
<td>3 max.</td>
<td>ASTM D 6637</td>
</tr>
<tr>
<td>Melting Point</td>
<td>°F (°C)</td>
<td>425 min. (218 min.)</td>
<td>ASTM D 276</td>
</tr>
</tbody>
</table>

161-2.3 SECURING PINS. Securing pins for geotextile fabric shall be secured with 9 inch (225 mm) steel staples having a 3/16 inch (5 mm) diameter with pointed ends. Geotextile fabric over Cement Treated Base (CTB) shall be secured with concrete nails with 1.5 inch (38 mm) diameter washers long enough to hold the fabric in place while the next pavement section is placed.

161-2.4 SEAMS. Seams shall be required in applications where stress transfer from one geotextile to another is necessary. Seaming may replace overlapping at the Contractor’s option.
Seam types shall be a flat or player seam, a “J” type seam, or a butterfly seam. A “J” type seam is preferred. Stitch counts (stitches per inch) shall range from 3 to 7. The standard stitch type shall be a chainstitch.

Sewing machinery shall make a double thread chainstitch, Type 401, and be capable of penetrating four layers of the geotextile. Machines may be hand held or table/equipment mounted, depending on fabric specified.

Sewing thread shall consist of nylon, polypropylene, polyester, or Kevlar thread.

A minimum 2 inches (50 mm) of fabric shall extend beyond the seam threads or a length sufficient to develop the required seam strength.

Seam strength shall be measured using grab-tensile procedures in accordance with ASTM D 4632. Seam efficiency is defined as the ratio of tensile strength across the seam to the strength of the intact fabric.

Factory sewing shall be utilized wherever possible to eliminate or reduce field seams.

161-2.5 DELIVERY, STORAGE, AND HANDLING OF MATERIAL. Geotextile materials delivered to site shall be inspected for damage, unloaded, and stored with the minimum of handling. Materials shall not be stored directly on the ground. During shipment and storage, filter cloth shall be furnished with a suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. Materials shall be handled in such a manner as to ensure delivery to the site in sound, undamaged condition.

Contractor shall furnish certified test reports with each shipment of material attesting that the fabric meets tile requirements of this Specification. Each roll shall be labeled or tagged to provide product identification sufficient for inventory and quality control purposes.

161-2.6 ASPHALT SEALANT. The material used to apply the pavement reinforcement grid, as well as bond it to both the base pavement and overlay, shall be the tack coat required in Item P-603. The Contractor shall furnish the vendor's certified test reports plus a one-quart sample for each carload or equivalent of bitumen shipped to the project. The report shall be delivered to the DEN Project Manager before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall be the basis for final acceptance of the material unless the DEN Project Manager requires tests run on the sample for conformance with AASHTO M 226.

161-2.7 AGGREGATE. Washed concrete sand may be spread over the asphalt saturated reinforcement grid to facilitate movement of equipment during construction or to prevent damage to the grid. Hot-mix broadcast in front of construction vehicle tires may also be used to serve this purpose for asphalt overlay projects. Excess quantities shall be removed from the grid prior to placing the surface course by blowing or sweeping.
CONSTRUCTION METHODS

161-3.1 GENERAL. The geotextile fabric shall be placed in the manner and at the locations shown in the Drawings or as directed by the DEN Project Manager.

At the time of installation, fabric shall be rejected if it has defects, ribs, holes, flaws, deterioration, or damage incurred during manufacture, transportation, storage, or placement. Visual review of the fabric shall be performed once the fabric has been placed and prior to placement of any overlying materials.

The fabric shall be placed with the machine direction (long dimension) down slope or normal to the natural slope, unless otherwise directed by the DEN Project Manager, and shall be laid smooth and free of tension, stress, folds, wrinkles, or creases. The strips shall be laid smooth to provide a minimum width of 12 inches (300 mm), or greater if specified, of overlap for each joint. Overlap Joints and seams shall be measured as a single layer of cloth.

Securing pins with washers shall be inserted through both strips of overlapped cloth at not greater than the following intervals along a line through the midpoint of the overlap. Securing pins are not necessarily required during installation for underdrains:

<table>
<thead>
<tr>
<th>Pin Spacing</th>
<th>Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 feet (0.60 m)</td>
<td>Steeper than 3:1</td>
</tr>
<tr>
<td>3 feet (1 m)</td>
<td>3:1 to 4:1</td>
</tr>
<tr>
<td>5 feet (1.5 m)</td>
<td>Flatter than 4:1</td>
</tr>
</tbody>
</table>

Additional pins regardless of location shall be installed as necessary to prevent any slippage of the filter fabric. Each securing pin shall be pushed through the fabric until the washer bears against the fabric and secures it firmly to the foundation. Bags of soil or other methods approved by the DEN Project Manager shall be used to secure the geotextile during installation.

The fabric shall be protected at all times during construction from contamination by surface runoff and any fabric so contaminated shall be removed and replaced with uncontaminated fabric.

Should the fabric be damaged during any of the installation, the torn or punctured section shall be repaired by placing a piece of fabric which extends at least 18 inches (450 mm) in all directions beyond the damaged area. The fabric shall be sewn, secured with pins and washers as described above, or other methods as approved by the DEN Project Manager.

161-3.2 PAVEMENT APPLICATIONS. Geotextiles shall be overlapped a minimum of 12 inches (300 mm) in the direction of flow.
Subbase shall be cleared of all sharp objects. Unroll geotextile fabric on prepared subbase. Provide minimum 18 inch (450 mm) overlap of material. Provide minimum 12 inch (300 mm) overlap of material with geotextile lining of underdrain trench.

Place overlying asphalt treated permeable base material in same direction as the geotextile overlap to avoid separation. Construction equipment other than hauling and paving equipment necessary for placement of the asphalt treated permeable base shall not be allowed on the geotextile. Operate hauling and paving equipment in a manner to prevent damage or displacement of the geotextile. Equipment shall avoid sudden acceleration, hard braking, and sharp turns while on the geotextile, and the paver shall not turn while on the geotextile. Large fabric wrinkles which may develop during the spreading operations shall be folded and flattened in the direction of the spreading. Special care shall be given to maintaining proper overlap and fabric continuity.

After placement of the asphalt treated permeable base, wrap geotextile around edge to completely surround exposed asphalt treated permeable base. The exposed fabric shall then be covered with the subsequent course.

Any damage to the fabric, such as tears, puncture, or excessive displacement, shall be repaired. The asphalt treated permeable base shall be removed from the top of from the fabric and the damaged area repaired as previously described Section 3.1.

161.3.3 STRESS-ABSORBING FABRIC (PAVEMENT REINFORCEMENT GRID).

a. Surface Preparation. This material will be placed between milled pavement and new bituminous surface course pavement. The asphalt surface on which the pavement reinforcement grid is to be placed shall be swept clean and inspected prior to installation to ensure it is free from dirt, rocks, asphalt millings, water, and any other foreign matter which could damage the grid fabric. Surface preparation shall meet the requirements of Item P-150 and shall be approved by the DEN Project Manager prior to placing the pavement reinforcement grid. In areas where existing crack filler is above the existing surface, it shall be trimmed to the existing surface. The contractor shall verify with the fabric manufacturer that the material may be placed over crack filler and sealants.

b. Weather Limitations. Neither the asphalt sealant nor the reinforcing grid shall be placed when weather conditions, in the opinion of the DEN Project Manager, are not suitable. Air and pavement temperatures shall be sufficient to allow the asphalt sealant to hold the reinforcing grid in place. For asphalt cements, air temperature shall be 50°F (10°C) and rising.

c. Application of Bituminous Material. The P-603 shall be uniformly spray-applied to the prepared dry pavement surface at the specified rate. The quantity specified will vary with the surface conditions but will normally be applied at the rate of 0.05 to 0.15 gallons per square yard (0.23 to 0.95 L/square meter) for pavement reinforcement grid, or as directed by the manufacturer of the material and approved by the DEN Project Manager.
Application of the bituminous material shall be by distributor spray bar, with hand spraying kept to a minimum. Temperature of the asphalt binder shall be sufficiently high to permit a uniform spray pattern. For asphalt cements, the minimum temperature shall be 290 °F (143°C). To avoid damage to the grid, however, the distributor tank temperature shall not exceed 325°F (163°C). The width of asphalt sealant shall be the width of the grid plus six inches. The asphalt sealant shall not be applied any farther in advance of grid placement than the distance which the Contractor can maintain free of traffic. All asphalt spills shall be cleaned thoroughly from the pavement surface to avoid flushing and grid movement. The rate of application shall be sufficient to satisfy the asphalt retention properties of the grid and bond the grid and overlay to the old pavement.

d. **Reinforcing Grid Placement.** The reinforcing grid shall be placed into the asphalt sealant with minimum wrinkling per the manufacturer’s recommendations once the tack coat has “broken”. In the event the asphalt sealant has lost tackiness, a new film of sealant will be placed. The reinforcing grid shall be unrolled and placed in accordance with manufacturer's recommendations. A qualified representative of the reinforcing grid manufacturer shall be present at the work site during the first stages of the grid placement to insure adequate workmanship and inspection of the grid placement.

e. **Bituminous Surface Course.** Placement of the bituminous surface course should closely follow pavement reinforcement grid laydown. The temperature of the P-401 or P-403 shall not exceed 325°F (163°C). In the event excessive asphalt sealant bleeds through the grid causing construction problems before the overlay is placed, the affected areas shall be blotted by spreading sand or hot-mix. To avoid movement or damage to the grid, turning of the paver and other vehicles shall be gradual and kept to a minimum. Any damage resulting from traffic crossing the grid shall be repaired to the satisfaction of the DEN Project Manager, at the Contractors expense. If, in the opinion of the DEN Project Manager, the grid surface appears dry and lacks tackiness a light coat of P-603 shall be applied prior to the bituminous surface course placement.

**METHOD OF MEASUREMENT**

161-4.1 **GEOTEXTILE FABRIC.** Geotextile fabric used in conjunction with pavement construction shall be measured by the number of square yards in-place based on the areas on the plans or approved by the DEN Project Manager and measured in the field. No allowance will be made for materials in laps, seams, or for waste trimmed.

161-4.2 **STRESS-ABSORBING FABRIC.** Measurement for payment of Stress-Absorbing Fabric shall be by the number of square yards of area covered measured in its final position. Pay quantities will be computed to the neat lines staked by the Contractor in accordance with the plans or as directed by the DEN Project Manager. Measurement will not include the lapping of transverse or longitudinal joints. P-603 associated with installation of the Stress-Absorbing Fabric will not be measured and is considered incidental to the installation.

**BASIS OF PAYMENT**
161-5.1 **GEOTEXTILE FABRIC.** Payment shall be made at the contract unit price per square yard for geotextile fabric. The price shall be full compensation for furnishing and placing all material and for all labor, equipment, tools, and incidentals necessary to complete the work prescribed in this item.

161-5.2 **STRESS ABSORBING FABRIC.** Payment shall be made at the contract unit price per square yard for Stress-Absorbing Fabric. The price shall be full compensation for furnishing all materials, for all preparation and placing the materials, and for all labor, equipment, tools, and incidentals necessary to complete the item. P-603 associated with the installation of Stress-Absorbing Fabric will not be paid for and is considered incidental to the installation.

Item P-161-5.1  Geotextile Fabric – Per Square Yard
Item P-161-5.2  Stress-Absorbing Fabric – Per Square Yard

**MATERIAL REQUIREMENTS**

ASTM D 5199  Method for Measuring Thickness of Textile Materials
ASTM D 5261  Test Method for Mass per Unit Area (Weight) of Woven Fabric
ASTM D 4355  Test Method for Deterioration of Geotextiles from Exposure to ultraviolet Light and Water (Xenon-Arc Type Apparatus)
ASTM D 4491  Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D 4533  Test Method for Trapezoid-Tearing Strength of Geotextiles
ASTM D 4632  Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
ASTM D 4751  Test Method for Determining the Apparent Opening Size of a Geotextile
ASTM D 4833  Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
ASTM D 6637  Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method
USEPA 9090  Compatibility Test for Wastes and Membrane Liners
AASHTO M226  Standard Specification for Viscosity-Graded Asphalt Cement

**END OF ITEM P-161**
ITEM P-401 HOT MIX ASPHALT (HMA) PAVEMENTS

DESCRIPTION

401-1.1 This item shall consist of pavement courses composed of mineral aggregate and asphalt cement binder (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.

The work set forth in this section consists of the Contractor’s preparation and submittal of an appropriate mix design, including the Contractor’s options with respect thereto, discussion of appropriate equipment for use by the Contractor and the placement of pavement composed of mineral aggregate and asphalt cement binder (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.

Section headings used in this Section P-401 or any other part of this Contract are for convenience only and shall not be used in the interpretation of this Section P-401 or any other section or subsection of this Contract so as to indicate that phrases or clauses describing standards, tests, equipment, workmanship, material descriptions, characteristics or results to be achieved are confined to the Section heading under which they appear. Any requirement appearing in one location shall be as binding as if appearing in all. It is the intention of this contract that the work will result in an end hot mix asphalt pavement product which is dense, homogeneous, without segregation.

MATERIALS

401-2.1 AGGREGATE. Aggregates shall consist of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. The aggregates should be free of ferrous sulfides, such as pyrite, that would cause “rust” staining that can bleed through pavement markings. The portion retained on the No. 4 (4.75 mm) sieve is coarse aggregate. The portion passing the No. 4 (4.75 mm) sieve and retained on the No. 200 (0.075 mm) sieve is fine aggregate, and the portion passing the No. 200 (0.075 mm) sieve is mineral filler.

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 bituminous material and free from organic matter and other deleterious substances. The
percentage of wear shall not be greater than 40% when tested in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 12%, or the magnesium sulfate soundness loss shall not exceed 18%, after five cycles, when tested in accordance with ASTM C88. Clay lumps and friable particles shall not exceed 1.0% when tested in accordance with ASTM C142.

Aggregate shall contain at least [ 75 ] percent by weight of individual pieces having two or more fractured faces and [ 85 ] percent by weight having at least one fractured face. The area of each face shall be equal to at least 75% of the smallest midsectional 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. Fractured faces shall be achieved by crushing.

[The aggregate shall not contain more than a total of 8%, by weight, of flat particles, elongated particles, and flat and elongated particles, when tested in accordance with ASTM D4791 with a value of 5:1.] [The aggregate shall not contain more than a total of 20% by weight of flat particles, elongated particles, and flat and elongated particles when tested in accordance with ASTM D4791 with a value of 3:1.]

[Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot (1.12 mg/cubic meter) when tested in accordance with ASTM C29.]

b. Fine aggregate. Fine aggregate shall consist of clean, sound, tough, durable, angular shaped particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter.

The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than six (6) and a liquid limit of not more than 25 when tested in accordance with ASTM D4318.

The soundness loss shall not exceed 10% when sodium sulfate is used or 15% when magnesium sulfate is used, after five cycles, when tested per ASTM C88.

Clay lumps and friable particles shall not exceed 1.0%, by weight, when tested in accordance with ASTM C142.

Natural (non-manufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification. [The fine aggregate shall not contain more than 15% natural sand by weight of total aggregates.] If used, the natural sand shall meet the requirements of ASTM D1073 and shall have a plasticity index of not more than six (6) and a liquid limit of not more than 25 when tested in accordance with ASTM D4318.
The aggregate shall have sand equivalent values of [40] or greater when tested in accordance with ASTM D2419.

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

### 401-2.2 MINERAL FILLER.

If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D242.

### 401-2.3 ASPHALT CEMENT BINDER.

Asphalt cement binder shall conform to ASTM D6373 Performance Grade (PG) [64-28]. A certificate of compliance from the manufacturer shall be included with the mix design submittal.

The supplier’s certified test report with test data indicating grade certification for the asphalt binder shall be provided to the DEN Project Manager for each load at the time of delivery to the mix plant. A certified test report with test data indicating grade certification for the asphalt binder shall also be provided to the DEN Project Manager for any modification of the asphalt binder after delivery to the mix plant and before use in the HMA.

A PG Plus Test will be required to determine if the asphalt cement binder has been properly modified. Use the PG Plus Test found in the Asphalt Institute’s State Binder Specification Database for the project location. When a State does not specify a PG Plus Test, use ASTM D6084 with a minimum elastic recovery of 70%.

### 401-2.4 PRELIMINARY MATERIAL ACCEPTANCE.

Prior to delivery of materials to the job site, the Contractor shall submit certified test reports to the DEN Project Manager for the following materials:

a. **Coarse aggregate:**

   (1) Percent of wear
   (2) Soundness
   (3) Clay lumps and friable particles
   (4) Percent fractured faces
   (5) Flat and elongated particles
   (6) [Unit weight of slag]

b. **Fine aggregate:**

   (1) Liquid limit and Plasticity index
   (2) Soundness
TECHNICAL SPECIFICATIONS

DIVISION 2 – AIRFIELD STANDARDS

ITEM P-401 HOT MIX ASPHALT (HMA) PAVEMENTS

DENVER INTERNATIONAL AIRPORT

2017 ANNUAL AIRFIELD PAVEMENT REHABILITATION

CONTRACT NO. 201733182

(3) Clay lumps and friable particles

(4) Percent natural sand

(5) Sand equivalent

c. Mineral filler.

d. Asphalt binder. Test results for asphalt binder shall include temperature/viscosity charts for mixing and compaction temperatures.

The certifications shall show the appropriate ASTM tests for each material, the test results, and a statement that the material meets the specification requirement.

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

401-2.5 ANTI-STRIPPING. Any anti-stripping agent or additive if required shall be heat stable, shall not change the asphalt cement viscosity beyond specifications, shall contain no harmful ingredients, shall be added in recommended proportion by approved method, and shall be a material approved by the Department of Transportation of the State in which the project is located.

COMPOSITION

401-3.1 COMPOSITION OF MIXTURE. The HMA mix shall be composed of a mixture of well-graded aggregate, filler and anti-stripping 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).

401-3.2 JOB MIX FORMULA (JMF). No hot-mixed asphalt (HMA) for payment shall be produced until a JMF has been approved in writing by the DEN Project Manager. The asphalt mix-design and JMF shall be prepared by an accredited laboratory that meets the requirements of paragraph 401-3.4. The HMA shall be designed using procedures contained in [ JMF ].

Tensile strength ratio (TSR) of the composite mixture, as determined by ASTM D4867, shall not be less than 75 when tested at a saturation of 70-80% or an anti-stripping agent shall be added to the HMA, as necessary, to produce a TSR of not less than 75 when tested at a saturation of 70-80%. If an anti-strip agent is required, it shall be provided by the Contractor at no additional cost to the Owner.

The JMF shall be submitted in writing by the Contractor at least [30] days prior to the start of paving operations. The JMF shall be developed within the same construction season using aggregates currently being produced.
The submitted JMF shall be stamped or sealed by the responsible professional Engineer of the laboratory and shall include the following items as a minimum:

a. Percent passing each sieve size for total combined gradation, individual gradation of all aggregate stockpiles and percent by weight of each stockpile used in the job mix formula.

b. Percent of asphalt cement.

c. Asphalt performance grade and type of modifier if used.

d. Number of blows pre side of specimen

e. Laboratory mixing temperature.

f. Laboratory compaction temperature.

g. Temperature-viscosity relationship of the PG asphalt cement binder showing acceptable range of mixing and compaction temperatures; and for modified binders include supplier recommended mixing and compaction temperatures.

h. Plot of the combined gradation on a 0.45 power gradation curve.

i. .

j. Specific Gravity and absorption of each aggregate.

k. Percent natural sand.

l. Percent fractured faces.

m. Percent by weight of flat particles, elongated particles, and flat and elongated particles (and criteria).

n. Tensile Strength Ratio (TSR).

o. Anti-strip agent (if required).

p. Date the JMF was developed. Mix designs that are not dated or which are from a prior construction season shall not be accepted.

q. [Percentage and properties (asphalt content, binder properties, and aggregate properties) of reclaimed asphalt pavement (RAP) in accordance with paragraph “Reclaimed Hot-Mix Asphalt,” if RAP is used.]

The Contractor shall submit to the DEN Project Manager the results of verification testing of three (3) asphalt samples prepared at the optimum asphalt content. The average of the results
of this testing shall indicate conformance with the JMF requirements specified in Tables 1 and 3.

When the project requires asphalt mixtures of differing aggregate gradations, a separate JMF and the results of JMF verification testing shall be submitted for each mix.

The JMF for each mixture shall be in effect until a modification is approved in writing by the DEN Project Manager. Should a change in sources of materials be made, a new JMF must be submitted within 15 days and approved by the DEN Project Manager in writing before the new material is used. After the initial production JMF has been approved by the DEN Project Manager and a new or modified JMF is required for whatever reason, the subsequent cost of the DEN Project Manager’s approval of the new or modified JMF, including a new test strip when required by the DEN Project Manager, will be borne by the Contractor. There will be no time extension given or considerations for extra costs associated with the stoppage of production paving or restart of production paving due to the time needed for the DEN Project Manager to approve the initial, new or modified JMF.

[Insert appropriate method here.]

Table 2. Minimum Percent Voids In Mineral Aggregate (VMA)

<table>
<thead>
<tr>
<th>Aggregate (See Table 3)</th>
<th>Minimum VMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradation 3</td>
<td>16%</td>
</tr>
<tr>
<td>Gradation 2</td>
<td>15%</td>
</tr>
<tr>
<td>Gradation 1</td>
<td>14%</td>
</tr>
</tbody>
</table>

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 3 when tested in accordance with ASTM C136 and ASTM C117.

The gradations in Table 3 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.

Table 3. Aggregate - HMA Pavements

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage by Weight Passing Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch (25 mm)</td>
<td>*</td>
</tr>
<tr>
<td>3/4 inch (19 mm)</td>
<td>100*</td>
</tr>
<tr>
<td>1/2 inch (12 mm)</td>
<td>79-99*</td>
</tr>
<tr>
<td>3/8 inch (9 mm)</td>
<td>68-88*</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>48-68*</td>
</tr>
<tr>
<td>No. 8 (2.36 mm)</td>
<td>33-53*</td>
</tr>
</tbody>
</table>
No. 16 (1.18 mm) 20-40*
No. 30 (0.60 mm) 14-30*
No. 50 (0.30 mm) 9-21*
No. 100 (0.15 mm) 6-16*
No. 200 (0.075 mm) 3-6*
Asphalt Percent:
Stone or gravel 5.0-7.5*
Slag 6.5-9.5*

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.

401-3.3 RECLAIMED ASPHALT PAVEMENT (RAP). [Reclaimed HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement. 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 pavement 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 401-3.2. RAP shall 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 [ ] percent. In addition to the requirements of paragraph 401-3.2, the JMF shall indicate the percent of reclaimed asphalt pavement and the percent and grade of new asphalt binder. For the PG graded asphalt binder selected in 401-2.3, adjust as follows:

a. For 0-20% RAP, there is no change in virgin binder content.

b. For >20 to 30% RAP, select binder one grade softer, i.e., PG 64-22 would soften to PG 58-28.]

[RAP shall not be used]

401-3.4 JOB MIX FORMULA (JMF) LABORATORY. The Contractor’s laboratory used to develop the JMF shall be accredited in accordance with ASTM D3666. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for developing the JMF must be listed on the lab accreditation. A
copy of the laboratory’s current accreditation and accredited test methods shall be submitted to the prior to start of construction.

401-3.5 TEST SECTION. Prior to full production, the Contractor shall prepare and place a quantity of HMA according to the JMF. The amount of HMA shall be sufficient to construct a test section [300 feet] long and [5 feet wide], placed in two lanes, with a longitudinal cold joint, and shall be of the same depth specified for the construction of the course which it represents. A cold joint for this test section is an exposed construction joint at least four (4) hours old or whose mat has cooled to less than 160°F (71°C). The cold joint must be cut back using the same procedure that will be used during production in accordance with 401-4.13. 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 evaluated for acceptance as a single lot in accordance with the acceptance criteria in paragraph 401-5.1 and 401-5.2. The test section shall be divided into equal sublots. As a minimum the test section shall consist of three (3) sublots.

The test section shall be considered acceptable if (1) [___], (2) gradation and asphalt content are within the action limits specified in paragraphs 401-6.5a and 5b, and (3) the voids in the mineral aggregate are within the limits of Table 2.

The test results shall be acceptable for the work to continue. If all of the test results meet the specified requirements, the test section shall remain as part of the project pavement. If test section is not considered acceptable, the test section shall be removed and replaced at no cost to the Owner and another test section shall be constructed.

If the initial test section should prove to be unacceptable, the necessary adjustments to the job mix formula, plant operation, placing procedures, and/or rolling procedures shall be made. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until an acceptable test section has been constructed and accepted in writing by the DEN Project Manager. Once an acceptable test section has been placed, payment for the test section that meets specification requirements shall be made in accordance with paragraph 401-8.1.

Job mix control testing shall be performed by the Contractor at the start of plant production and in conjunction with the calibration of the plant for the JMF. If aggregates produced by the plant do not satisfy the gradation requirements or produce a mix that meets the JMF, it will be necessary to reevaluate and redesign the mix using plant-produced aggregates. Specimens shall be prepared and the optimum asphalt content determined in the same manner as for the original JMF tests.

Contractor will not be allowed to place the test section until the Contractor Quality Control Program, showing conformance with the requirements of Paragraph 401-6.1, has been approved, in writing, by the DEN Project Manager.
CONSTRUCTION METHODS

401-4.1 WEATHER LIMITATIONS. The HMA 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 DEN Project Manager, if requested; however, all other requirements including compaction shall be met.

<table>
<thead>
<tr>
<th>Mat Thickness</th>
<th>Base Temperature (Minimum)</th>
<th>°F</th>
<th>°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inches (7.5 cm) or greater</td>
<td>40</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Greater than 2 inches (50 mm) but less than 3 inches (7.5 cm)</td>
<td>45</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

401-4.2 HMA PLANT. Plants used for the preparation of HMA shall conform to the requirements of American Association of State Highway and Transportation Officials (AASHTO) M156 with the following changes:

Requirements for all plants include:

a. Truck scales. The HMA shall be weighed on approved scales furnished by the Contractor, or on certified public scales at the Contractor’s expense. Scales shall be inspected and sealed as often as the DEN Project Manager deems necessary to assure their accuracy. Scales shall conform to the requirements of the General Provisions, subsection 90-01.

In lieu of scales, and as approved by the DEN Project Manager, HMA weight may be determined by the use of an electronic weighing system equipped with an automatic printer that weighs the total HMA production and as often thereafter as requested by the DEN Project Manager.

b. Testing facilities. The Contractor shall ensure laboratory facilities are provided at the plant for the Contractor’s quality control testing and use of the DEN Project Manager. The lab shall have sufficient space so that both testing representatives (DEN Project Manager’s and Contractor’s) can operate efficiently. The lab shall meet the requirements of ASTM D3666 including all necessary equipment, materials, calibrations, current reference standards to comply with the specifications and a masonry saw with diamond blade for trimming pavement cores and samples.

The laboratory shall be weather tight, sufficiently heated in cold weather, air-conditioned in hot weather to maintain temperatures for testing purposes of 70°F ±5°F (21°C ±2.3°C). The plant testing laboratory shall be located on the plant site to provide an unobstructed view, from one of its windows, of the trucks being loaded with the plant mix materials. Failure to
provide the specified facilities shall be sufficient cause for disapproving HMA plant operations.

Laboratory facilities shall be kept clean, and all equipment shall be maintained in proper working condition. The DEN Project Manager shall be permitted unrestricted access to inspect the Contractor’s laboratory facility and witness quality control activities. The DEN Project Manager will advise the Contractor in writing of any noted deficiencies concerning the laboratory 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.

c. **Inspection of Plant.** The DEN Project Manager, or DEN Project 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.

d. **Storage bins and surge bins.** The HMA stored in storage and surge bins shall meet the same requirements as HMA loaded directly into trucks and may be permitted under the following conditions:

1. Stored in non-insulated bins for a period of time not to exceed three (3) hours.
2. Stored in insulated bins for a period of time not to exceed eight (8) hours.

If the DEN Project Manager determines that there is an excessive amount of heat loss, segregation, or oxidation of the HMA due to temporary storage, no temporary storage will be allowed.

**401-4.3 HAULING EQUIPMENT.** Trucks used for hauling HMA shall have tight, clean, and smooth metal beds. To prevent the HMA 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 DEN Project 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.

a. **Material Transfer Vehicle (MTV).** [Material transfer vehicles used to transfer the material from the hauling equipment to the paver, shall 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.] [Material transfer vehicles are not required.]

401-4.4 **HMA Pavers.** HMA pavers shall be self-propelled with an activated heated screed, capable of spreading and finishing courses of HMA 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 paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the HMA uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

If, during construction, it is found that 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 and satisfactory equipment shall be provided by the Contractor.

**a. Automatic Grade Controls.** The HMA paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices that will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within ±0.1%.

The controls shall be capable of working in conjunction with any of the following attachments:

1. Ski-type device of not less than 30 feet in length.
2. Taut string-line (wire) set to grade.
3. Short ski or shoe.
4. Laser control.

401-4.5 **Rollers.** Rollers of the vibratory, steel wheel, and pneumatic-tired type shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the HMA. The number, type, and weight of rollers shall be sufficient to compact the HMA to the required density while it is still in a workable condition.

All rollers shall be specifically designed and suitable for compacting HMA 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. Depressions in pavement surfaces caused by rollers shall be repaired by the Contractor at their own expense.
The use of equipment that causes crushing of the aggregate will not be permitted.

**401-4.6 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 gauge and obtain accurate density readings for all new HMA. These densities shall be supplied to the DEN Project Manager upon request at any time during construction. No separate payment will be made for supplying the density gauge and technician.

**401-4.7 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 binder to the mixer at a uniform temperature. The temperature of 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°F (160°C) when added to the aggregate. The temperature of modified asphalt binder shall be no more than 350°F (175°C) when added to the aggregate.

**401-4.8 PREPARATION OF MINERAL AGGREGATE.** The aggregate for the HMA 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.

**401-4.9 PREPARATION OF HMA.** 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 will be set to achieve 95% of coated particles. For continuous mix plants, the minimum 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 HMA upon discharge shall not exceed 0.5%.

**401-4.10 PREPARATION OF THE UNDERLYING SURFACE.** Immediately before placing the HMA, the underlying course shall be cleaned of all dust and debris. [A prime coat shall be applied in accordance with Item P-602, if shown on the plans.] A tack coat is required: between the existing pavement surface and the new hot mix asphalt, including milled surfaces; between layers of each lift of hot mix asphalt; and at any vertical surfaces that the new hot mix asphalt will be placed against including cold joints. Tack coat must be applied in accordance with Item P-603.
401-4.11 LAYDOWN PLAN, TRANSPORTING, PLACING, AND FINISHING.

Prior to the placement of the HMA, the Contractor shall prepare a laydown plan for approval by the DEN Project Manager. This is to minimize the number of cold joints in the pavement. The laydown plan shall include the sequence of paving laydown by stations, width of lanes, temporary ramp locations, and laydown temperature. The laydown plan shall also include estimated time of completion for each portion of the work (that is, milling, paving, rolling, cooling, etc.). Modifications to the laydown plan shall be approved by the DEN Project Manager.

The HMA shall be transported from the mixing plant to the site in vehicles conforming to the requirements of paragraph 401-4.3. Deliveries shall be scheduled so that placing and compacting of HMA 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 atmospheric temperature.

[The Contractor shall use a material transfer vehicle to deliver HMA to the paver.]

The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose for the first lift of all runway and taxiway pavements. Successive lifts of HMA surface course may be placed using a ski, or laser control per paragraph 401-4.4.1, provided grades of the first lift of HMA surface course meet the tolerances of paragraphs 401-5.2(b)(6) as verified by a survey. Contractor shall survey each lift of HMA surface course and certify to DEN Project Manager that every lot of each lift meets the grade tolerances of paragraph 401-5.2(b)(6) before the next lift can be placed.

The initial placement and compaction of the HMA shall occur at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 250°F (121°C), unless otherwise indicated in the approved mix design.

Edges of existing HMA pavement abutting the new work shall be saw cut and carefully removed as shown on the drawings and coated with asphalt tack coat before new material is placed against it.

Upon arrival, the HMA shall be placed to the full width by a HMA paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the HMA mat. Unless otherwise permitted, placement of the HMA shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The HMA shall be placed in consecutive adjacent strips having a minimum width of [ ___ ] feet (m) except where edge lanes require less width to complete the area. Additional screed sections shall not be attached to widen paver to meet the minimum lane width requirements specified above unless additional auger sections are added to match. 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 HMA may be spread and luted by hand tools.

Areas of segregation in the surface course, as determined by the DEN Project Manager, shall be removed and replaced at the Contractor’s expense. The area shall be removed by saw cutting and milling a minimum of 2 inches (50 mm) deep. The area to be removed and replaced shall be a minimum width of the paver and a minimum of 10 feet (3 m) long.

401-4.12 COMPACTION OF HMA. After placing, the HMA shall be thoroughly and uniformly compacted by power rollers. The surface shall be compacted as soon as possible when the HMA 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 displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

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 HMA to the roller, the wheels shall be equipped with a scraper and kept properly moistened but excessive water will not be permitted.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with approved power driven tampers. Tampers shall weigh not less than 275 pounds (125 kg), have a tamping plate width not less than 15 inches (38 cm), be rated at not less than 4,200 vibrations per minute, and be suitably equipped with a standard tamping plate wetting device.

Any HMA 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.

401-4.13 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 HMA 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 HMA against the joint.
Longitudinal joints which 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 3 inches (75 mm) to 6 inches (150 mm) to expose a clean, sound, uniform vertical surface for the full depth of the course. All cutback material shall be removed from the project. Asphalt tack coat or other product approved by the DEN Project Manager shall be applied to the clean, dry joint, prior to placing any additional fresh HMA against the joint. Any laitance produced from cutting joints shall be removed by vacuuming and washing. The cost of this work shall be considered incidental to the cost of the HMA.

401-4.14 SAW-CUT GROOVING. If shown on the plans, saw cut grooves shall be provided as specified in Item P-621.

401-4.15 DIAMOND GRINDING. When required, diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the pavement. The saw blades shall be 1/8-inch (3-mm) wide and there shall be a minimum of 55 to 60 blades per 12 inches (300 mm) of cutting head width; the actual number of blades will be determined by the Contractor and depend on the hardness of the aggregate. Each machine shall be capable of cutting a path at least 3 feet (0.9 m) wide. Equipment that causes ravels, aggregate fractures, spalls or disturbance to the pavement will not be permitted. The depth of grinding shall not exceed 1/2 inch (13mm) and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. Areas that have been ground will be sealed with a surface treatment as directed by the DEN Project Manager. It may be necessary to seal a larger area to avoid surface treatment creating any conflict with runway or taxiway markings.

401-4.16 NIGHTTIME PAVING REQUIREMENTS. Paving during nighttime construction shall require the following:

a. All paving machines, rollers, distribution trucks and other vehicles required by the Contractor for his operations shall be equipped with artificial illumination sufficient to safely complete the work.

b. Minimum illumination level shall be twenty (20) horizontal foot-candles and maintained in the following areas:

   (1) An area of 30 feet (9 m) wide by 30 feet (9 m) long immediately behind the paving machines during the operations of the machines.

   (2) An area 15 feet (4.5 m) wide by 30 feet (9 m) long immediately in front and back of all rolling equipment, during operation of the equipment.

   (3) An area 15 feet (4.5 m) wide by 15 feet (4.5 m) long at any point where an area is being tack coated prior to the placement of pavement.
c. As partial fulfillment of the above requirements, the Contractor shall furnish and use, complete artificial lighting units with a minimum capacity of 3,000 watt electric beam lights, affixed to all equipment in such a way to direct illumination on the area under construction.

d. A lighting plan must be submitted by the Contractor and approved by the DEN Project Manager prior to the start of any nighttime work.

MATERIAL ACCEPTANCE

401-5.1 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 DEN Project Manager at no cost to the Contractor except that coring [and profilograph testing] as required in this section shall be completed and paid for by the Contractor.

Testing organizations performing these tests [except profilograph] shall be accredited in accordance with ASTM D3666. The 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 shall be submitted to the DEN Project Manager prior to start of construction. All equipment in Contractor furnished laboratories shall be calibrated by an independent testing organization prior to the start of operations at the Contractor’s expense.

a. **Hot mixed asphalt.** Plant-produced HMA shall be tested for air voids [ ] on a lot basis. Sampling shall be from material deposited in place prior to compaction. Samples shall be taken in accordance with ASTM D979.

A standard lot shall be equal to one day’s production or 2000 tons (1814 metric tons) whichever is smaller. If the day’s production is expected to exceed 2000 tons (1814 metric tons), but less than 4000 tons (3628 metric tons), the lot size shall be 1/2 day’s production. If the day’s production exceeds 4000 tons (3628 metric tons), the lot size shall be an equal sized fraction of the day’s production, but shall not exceed 2000 tons (1814 metric tons).

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

(1) **Sampling.** Each lot will consist of four equal sublots. Sufficient HMA for preparation of test specimens for all testing will be sampled by the DEN Project Manager on a random basis, in accordance with the procedures contained in ASTM D3665. Samples will be taken in accordance with ASTM D979.

The sample of HMA may be put in a covered metal tin and placed in an oven for not less than 30 minutes nor more than 60 minutes to stabilize to compaction temperature. The compaction temperature of the specimens shall be as specified in the JMF.
(2) Testing. [ ]

Prior to testing, the bulk specific gravity of each test specimen shall be measured by the DEN Project Manager in accordance with [ASTM D2726] [ASTM D6752] using the procedure for laboratory-prepared thoroughly dry specimens for use in computing air voids and pavement density. ASTM D7227 may be used to expedite test results.

For air voids determination, the theoretical maximum specific gravity of the mixture shall be measured one time for each subplot in accordance with ASTM D2041. The value used in the air voids computation for each subplot shall be based on theoretical maximum specific gravity measurement for the subplot.

[The stability and flow for each subplot shall be computed by averaging the results of all test specimens representing that subplot.]

(3) Acceptance. [___]

b. In-place HMA. HMA placed in the field shall be tested for mat and joint density on a lot basis. A standard lot shall be equal to one day’s production or 2000 tons (1814 metric tons) whichever is smaller. If the day’s production is expected to exceed 2000 tons (1814 metric tons), but less than 4000 tons (3628 metric tons), the lot size shall be 1/2 day’s production. If the day’s production exceeds 4000 tons (3628 metric tons), the lot size shall be an equal sized fraction of the day’s production, but shall not exceed 2000 tons (1814 metric tons).

1. Mat density. The lot size shall be the same as that indicated in paragraph 401-5.1a and shall be divided into four equal sublots. One core of finished, compacted HMA shall be taken by the Contractor from each subplot. Core locations will be determined by the DEN Project Manager on a random basis in accordance with procedures contained in ASTM D3665. Cores for mat density shall not be taken closer than one foot (30 cm) from a transverse or longitudinal joint.

2. Joint density. The lot size shall be the total length of longitudinal joints constructed by a lot of HMA as defined in paragraph 401-5.1a. The lot shall be divided into four equal sublots. One core of finished, compacted HMA shall be taken by the Contractor from each subplot. Core locations will be determined by the DEN Project Manager on a random basis in accordance with procedures contained in ASTM D3665. All cores for joint density shall be taken centered on the joint. The minimum core diameter for joint density determination shall be 5 inches (125 mm).

3. Sampling. Samples shall be neatly cut with a diamond core drill bit. Samples will be taken in accordance with ASTM D979. The minimum diameter of the sample shall be 5 inches (125 mm). Samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. The Contractor shall furnish all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Cored pavement shall be cleaned and core holes shall be filled in a manner acceptable to the DEN
Project Manager and within one day after sampling. Laitance produced by the coring operation shall be removed immediately.

The top most lift of HMA shall be completely bonded to the underlying layer. If any of the cores reveal that the surface is not bonded to the layer immediately below the surface then additional cores shall be taken as directed by the DEN Project Manager in accordance with paragraph 401-5.1b to determine the extent of any delamination. All delaminated areas shall be completely removed by milling to the limits and depth and replaced as directed by the DEN Project Manager at no additional cost.

(4) **Testing.** The bulk specific gravity of each cored sample will be measured by the DEN Project Manager in accordance with [ASTM D2726] [ASTM D6752]. Samples will be taken in accordance with ASTM D979. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each sublot sample by the average bulk specific gravity of all laboratory prepared specimens for the lot, as determined in paragraph 401-5.1a(2). The bulk specific gravity used to determine the joint density at joints formed between different lots shall be the lowest of the bulk specific gravity values from the two different lots.

(5) **Acceptance.** Acceptance of field placed HMA for mat density will be determined by the DEN Project Manager in accordance with the requirements of paragraph 401-5.2b(1). Acceptance for joint density will be determined by the DEN Project Manager in accordance with the requirements of paragraph 401-5.2b(3).

c. **Partial lots.** When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and DEN Project Manager agree in writing to allow overages or other minor tonnage 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.

The last batch produced where production is halted will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. In addition, an agreed to minor placement will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. Where three sublots are produced, they shall constitute a lot. Where one or two sublots are produced, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation, that is, n = 5 or n = 6, for example. Partial lots at the end of asphalt production on the project shall be included with the previous lot. The lot size for field placed material shall correspond to that of the plant material, except that, in no cases, shall less than three (3) cored samples be obtained, that is, n = 3.

**401-5.2 ACCEPTANCE CRITERIA.**

a. **General.** Acceptance will be based on the following characteristics of the HMA and completed pavement as well as the implementation of the Contractor Quality Control Program and test results:
Mat density and air voids will be evaluated for acceptance in accordance with paragraph 401-5.2b(1). **[Stability and flow will be evaluated for acceptance in accordance with paragraph 401-5.2b(2).]** Joint density will be evaluated for acceptance in accordance with paragraph 401-5.2b(3).

Thickness will be evaluated by the DEN Project Manager for compliance in accordance with paragraph 401-5.2b(4). Acceptance for smoothness will be based on the criteria contained in paragraph 401-5.2b(5). Acceptance for grade will be based on the criteria contained in paragraph 401-5.2b(7).

The DEN Project Manager may at any time, reject and require the Contractor to dispose of any batch of HMA which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. 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 DEN Project Manager, and if it can be demonstrated in the laboratory, in the presence of the DEN Project Manager, that such material was erroneously rejected, payment will be made for the material at the contract unit price. DEN Project Manager shall review and approve laboratory testing plan.

b. **Acceptance Criteria.**

(1) **Mat density and air voids.** Acceptance of each lot of plant produced material for mat density and air voids shall be based on the percentage of material within specification limits (PWL). If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable. Acceptance and payment shall be determined in accordance with paragraph 401-8.1.

(2) **[Stability [and flow].** Acceptance of each lot of plant produced HMA for stability and flow shall be based on the PWL. If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable. If the PWL is less than 90%, the Contractor shall determine the reason and take corrective action. If the PWL is below 80%, the
Contractor must stop production until the reason for poor stability and/or flow has been determined and adjustments to the HMA are made.]

(3) **Joint density.** Acceptance of each lot of plant produced HMA for joint density shall be based on the PWL. If the PWL of the lot is equal to or exceeds 90%, the lot shall be considered acceptable. If the PWL is less than 90%, the Contractor shall evaluate the reason and act accordingly. If the PWL is less than 80%, the Contractor shall cease operations and until the reason for poor compaction has been determined. If the PWL is less than 71%, the pay factor for the lot used to complete the joint shall be reduced by five (5) percentage points. This lot pay factor reduction shall be incorporated and evaluated in accordance with paragraph 401-8.1.

(4) **Thickness.** Thickness of each lift of surface course shall be evaluated by the DEN Project Manager for compliance to the requirements shown on the plans. Measurements of thickness shall be made by the DEN Project Manager using the cores extracted for each sublot for density measurement. The maximum allowable deficiency at any point shall not be more than 1/4 inch (6 mm) less than the thickness indicated for the lift. Average thickness of lift, or combined lifts, shall 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 DEN Project Manager to circumscribe the deficient area.

(5) **Smoothness.** The final surface shall be free from roller marks. After the final rolling, but not later than 24 hours after placement, the surface of each lot shall be tested in both longitudinal and transverse directions for smoothness to reveal all surface irregularities exceeding the tolerances specified. The Contractor shall furnish paving equipment and employ methods that produce a surface for each pavement lot having an average profile index meeting the requirements of paragraph 401-8.1d when evaluated with a profilograph; and the finished surface course of the pavement shall not vary more than 1/4 inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. When the surface course smoothness exceeds specification tolerances which cannot be corrected by diamond grinding of the surface course, full depth removal and replacement of surface course corrections shall be to the limit of the longitudinal placement. Corrections involving diamond grinding will be subject to the final pavement thickness tolerances specified. The Contractor shall apply a surface treatment to all areas that have been subject to grinding as directed by the DEN Project Manager.

(a) **Transverse measurements.** Transverse measurements will be taken for each lot placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50 feet (15m) or more often as determined by the DEN Project Manager.

   i) Testing shall be continuous across all joints, starting 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. Smoothness readings will not be made across grade changes or cross slope transitions; at
these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. The amount of 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 these two high points. High spots on final surface course > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 401-4.15 or by removing and replacing full depth of surface course. Grindimg will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

ii) The joint between lots shall be tested separately to facilitate smoothness between lots. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface, with half the straightedge on one side of the joint and the other half of the straightedge on the other side of the joint. Measure the maximum gap between the straightedge and the pavement surface in the area between these two high points. One measurement shall be taken at the joint every 50 feet (15m) or more often if directed by the DEN Project Manager. Deviations on final surface course > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 401-4.15 or by removing and replacing full depth of surface course. Each measurement shall be recorded and a copy of the data shall be furnished to the DEN Project Manager at the end of each days testing.

(b) Longitudinal measurements. Longitudinal measurements will be taken for each lot 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 (6m); and at the third points of paving lanes when widths of paving lanes are 20 ft (6m) or greater.

i) Longitudinal Short Sections. Longitudinal Short Sections are when the longitudinal lot length is less than 200 feet (60m) and areas not requiring a profilograph. When approved by the DEN Project Manager, the first and last 15 feet (4.5m) of the lot can also be considered as short sections for smoothness. The finished surface shall not vary more than 1/4 inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. Testing shall be continuous across all joints, starting 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. The amount of 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 these two high points. Deviations on final surface course > 1/4 inch (6mm) in longitudinal direction will be corrected with diamond grinding per paragraph 401-4.15 or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to
provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

ii) Profilograph Testing. Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2 inch (5 mm) blanking band. The bump template must span one inch (25 mm) with an offset of 0.4 inches (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved operator. Profilograms shall be recorded on a longitudinal scale of one inch (25 mm) equals 25 feet (7.5 m) and a vertical scale of one inch (25 mm) equals one inch (25 mm). A copy of the reduced tapes shall be furnished to the DEN Project Manager at the end of each days testing.

The pavement must have an average profile index meeting the requirements of paragraph 401-8.1d. High spots, or “must grind” spots, on final surface course in longitudinal direction shall be corrected with diamond grinding per paragraph 401-4.15 or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

Where corrections are necessary, second profilograph runs shall be performed to verify that the corrections produced an average profile index of 15 inches (38 cm) per mile or less. If the initial average profile index was less than 15 inches (38 cm), only those areas representing greater than 0.4 inch (10 mm) deviation will be re-profiled for correction verification.

iii) Final profilograph of [runway]. Final profilograph, full length of runway, shall be performed to facilitate testing of smoothness between lots. Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The pavement must have an average profile index meeting the requirements of paragraph 401-8.1d. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2 inch (5 mm) blanking band. The bump template must span one inch (25 mm) with an offset of 0.4 inches (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved, trained operator. Profilograms shall be recorded on a longitudinal scale of one inch (25 mm) equals 25 feet (7.5 m) and a vertical scale of one inch (25 mm) equals one inch (25 mm). A copy of the reduced tapes shall be furnished to the DEN Project Manager at the end of each days testing. Profilograph of final runway shall be performed one foot right and left of runway centerline and 15 feet (4.5 m) right and left of centerline. Any areas that indicate “must grind” will be corrected as directed by the DEN Project Manager.

Smoothness testing indicated in the above paragraphs except paragraph (iii) shall be performed within 24 hours of placement of material. Smoothness testing indicated in paragraph (iii) shall be performed within 48 hours of paving completion. The primary purpose of smoothness testing is to identify areas that may be prone to ponding of water
which could lead to hydroplaning of aircraft. If the contractor’s machines and/or methods are producing significant areas that need corrective actions then production should be stopped until corrective measures can be implemented. If corrective measures are not implemented and when directed by the DEN Project Manager, production shall be stopped until corrective measures can be implemented.

(6) Grade. Grade shall be evaluated on the first day of placement and then as a minimum, every [ ] to allow adjustments to paving operations if measurements do not meet specification requirements. The Contractor must submit the survey data to the DEN Project Manager by the following day after measurements have been taken. The finished surface of the pavement shall not vary from the gradeline elevations and cross-sections shown on the plans by more than 1/2 inch (12 mm). The finished grade of each lot will be determined by running levels at intervals of 50 feet (15 m) or less longitudinally and all breaks in grade transversely (not to exceed 50 feet (15 m)) to determine the elevation of the completed pavement. The Contractor shall pay the cost of surveying of the level runs that shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the DEN Project Manager. The lot size shall be [ ] square yards (m²). When more than 15% of all the measurements within a lot are outside the specified tolerance, or if any one shot within the lot deviates 3/4 inch (19 mm) or more from planned grade, the Contractor shall remove the deficient area to the depth of the final course plus 1/2 inch (12 mm) of pavement and replace with new material. Skin patching shall not be permitted. Isolated high points may be ground off provided the course thickness complies with the thickness specified on the plans. The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130 inches (2 and 3.5 mm) wide. The peaks and ridges shall be approximately 1/32 inch (1 mm) higher than the bottom of the grooves. The pavement shall be left in a clean condition. The removal of all of the slurry resulting from the grinding operation shall be continuous The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement. High point grinding will be limited to 15 square yards (12.5 m²). Areas in excess of 15 square yards (12.5 m²) will require removal and replacement of the pavement in accordance with the limitations noted above. The Contractor shall apply a surface treatment as directed by the Engineer to all areas that have been subject to grinding.

c. Percentage of Material Within Specification Limits (PWL). The PWL shall be determined in accordance with procedures specified in Section 110 of the General Provisions. The specification tolerance limits (L) for lower and (U) for upper are contained in Table 5.

[Insert appropriate method here]

d. Outliers. All individual tests for mat density and air voids shall be checked for outliers (test criterion) in accordance with ASTM E178, at a significance level of 5%. Outliers shall be discarded, and the PWL shall be determined using the remaining test values. The criteria in Table 5 is based on production processes which have a variability with the following standard deviations: Surface Course Mat Density (%), 1.30; Base Course Mat Density (%), 1.55; Joint Density (%), 2.1.
The Contractor should note that (1) 90 PWL is achieved when consistently producing a surface course with an average mat density of at least 98% with 1.30% or less variability, (2) 90 PWL is achieved when consistently producing a base course with an average mat density of at least 97.5% with 1.55% or less variability, and (3) 90 PWL is achieved when consistently producing joints with an average joint density of at least 96% with 2.1% or less variability.

401-5.3 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 DEN Project Manager. A retest will consist of all the sampling and testing procedures contained in paragraphs 401-5.1b and 401-5.2b(1). Only one resampling per lot will be permitted.

(1) A redefined PWL shall be calculated for the resampled lot. The number of tests used to calculate the redefined PWL shall 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 PWL for a resampled lot shall be used to calculate the payment for that lot in accordance with Table 6.

c. Outliers. Check for outliers in accordance with ASTM E178, at a significance level of 5%.

401-5.4 [LEVELING COURSE. Any course used for trueing and leveling shall meet the aggregate gradation in Table 3, paragraph 401-3.2. The trueing and leveling course shall meet the requirements of paragraph 401-3.2, 401-5.2b(1) for air voids [and 401-5.2b(2) for stability and flow], but shall not be subject to the density requirements of paragraph 401-5.2b(1) for mat density and 401-5.2b(3) for joint density. The leveling course shall be compacted with the same effort used to achieve density of the test section. The trueing and leveling course shall not exceed the maximum lift thickness associated with each gradation in Table 3, paragraph 401-3.2. The leveling course is the first variable thickness lift of an overlay placed prior to subsequent courses.]

CONTRACTOR QUALITY CONTROL

401-6.1 GENERAL. The Contractor shall develop a Quality Control Program in accordance with Section 100 of the General Provisions. The program shall address all elements that affect the quality of the pavement including, but not limited to:

a. Mix Design

b. Aggregate Grading
c. Quality of Materials
d. Stockpile Management
e. Proportioning
f. Mixing and Transportation
g. Placing and Finishing
h. Joints
i. Compaction
j. Surface Smoothness
k. Personnel
l. Laydown Plan

The Contractor shall perform quality control sampling, testing, and inspection during all phases of the work and shall perform them at a rate sufficient to ensure that the work conforms to the contract requirements, and at minimum test frequencies required by paragraph 401-6.3 and Section 100 of the General Provisions. As a part of the process for approving the Contractor’s plan, the DEN Project Manager may require the Contractor’s technician to perform testing of samples to demonstrate an acceptable level of performance.

No partial payment will be made for materials that are subject to specific quality control requirements without an approved plan.

401-6.2 CONTRACTOR TESTING LABORATORY. The lab shall meet the requirements of ASTM D3666 including all necessary equipment, materials, and current reference standards to comply with the specifications.

401-6.3 QUALITY CONTROL TESTING. The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to these specifications and as set forth in the approved Quality Control Program. 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 Quality Control Testing Plan shall be developed as part of the Quality Control Program.

a. Asphalt Content. A minimum of two asphalt content tests shall be performed per lot in accordance with ASTM D6307 or ASTM D2172 if the correction factor in ASTM D6307 is greater than 1.0. The asphalt content for the lot 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, 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 HMA.** The moisture content shall be determined once per lot in accordance with [ASTM D1461] or CDOT Procedure CP43.

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 HMA at the plant, and the HMA 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. **Additional Testing.** Any additional testing that the Contractor deems necessary to control the process may be performed at the Contractor’s option.

h. **Monitoring.** The DEN Project Manager reserves the right to monitor any or all of the above testing.

401-6.4 **SAMPLING.** When directed by the DEN Project 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.

401-6.5 **CONTROL CHARTS.** The Contractor shall maintain linear control charts both for individual measurements and range (that is, difference between highest and lowest measurements) for aggregate gradation, asphalt content, and VMA. The VMA for each sublot will be calculated and monitored by the Quality Control laboratory.

Control charts shall be posted in a location satisfactory to the DEN Project Manager and shall be 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 DEN Project 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 job mix formula target values as
indicators of central tendency for the following test parameters with associated Action and Suspension Limits:

<table>
<thead>
<tr>
<th>Control Chart Limits For Individual Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sieve</strong></td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>3/4 inch (19 mm)</td>
</tr>
<tr>
<td>1/2 inch (12 mm)</td>
</tr>
<tr>
<td>3/8 inch (9 mm)</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
</tr>
<tr>
<td>No. 50 (0.30 mm)</td>
</tr>
<tr>
<td>No. 200 (0.075 mm)</td>
</tr>
<tr>
<td>Asphalt Content</td>
</tr>
<tr>
<td>VMA</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Control Chart Limits Based On Range (Based On n = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sieve</strong></td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>1/2 inch (12 mm)</td>
</tr>
<tr>
<td>3/8 inch (9 mm)</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
</tr>
<tr>
<td>No. 50 (0.30 mm)</td>
</tr>
<tr>
<td>No. 200 (0.075 mm)</td>
</tr>
<tr>
<td>Asphalt Content</td>
</tr>
</tbody>
</table>

c. **Corrective Action.** The Contractor Quality Control Program 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; or

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

401-6.6 QUALITY CONTROL REPORTS. The Contractor shall maintain records and shall submit reports of quality control activities daily, in accordance with the Contractor Quality Control Program described in General Provisions, Section 100.

401-6.7 QUALITY CONTROL/QUALITY ASSURANCE TESTING SUMMARY. Unless stated otherwise, all testing is conducted by the Contractor. All necessary field and laboratory testing shall be considered incidental to the work and no additional payment will be made.

The following table summarizes the testing required in this specification. The information included in this table does not waive any requirements listed previously in the specification. All test results shall be provided to the DEN Project Manager within 48 hours of completion of the tests.

<table>
<thead>
<tr>
<th>Specification Reference</th>
<th>Test Type</th>
<th>Test Standard</th>
<th>Minimum Testing Frequency</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1a &amp; 2.4a</td>
<td>Coarse Aggregate – Material Properties and Quality</td>
<td>ASTM C131, ASTM C88, ASTM C142, Fractured Faces, ASTM D4791 [ASTMC29]</td>
<td>For each job mix formula approval</td>
<td>Contractor</td>
</tr>
<tr>
<td>2.1b &amp; 2.4b</td>
<td>Fine Aggregate – Material Properties and Quality</td>
<td>ASTM D4318, ASTM C88, ASTM C142, ASTM D2419</td>
<td>For each job mix formula approval</td>
<td>Contractor</td>
</tr>
<tr>
<td>Specification Reference</td>
<td>Test Type</td>
<td>Test Standard</td>
<td>Minimum Testing Frequency</td>
<td>Responsible Party</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------------------------------------</td>
<td>----------------------------------------</td>
<td>-------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>2.1b &amp; 2.4b</td>
<td>Natural Sand – Material Properties and Quality</td>
<td>ASTM D1073, ASTM D4318</td>
<td>For each job mix formula approval (if applicable)</td>
<td>Contractor</td>
</tr>
<tr>
<td>2.2 &amp; 2.4c</td>
<td>Mineral Filler - Material Properties and Quality</td>
<td>ASTM D242</td>
<td>For each job mix formula approval (if applicable)</td>
<td>Contractor</td>
</tr>
<tr>
<td>2.3 &amp; 2.4d</td>
<td>Asphalt Cement Binder</td>
<td>ASTM D6373, ASTM D6084</td>
<td>For each job mix formula, and each load delivered to project</td>
<td>Contractor</td>
</tr>
<tr>
<td>3.2 &amp; 3.5</td>
<td>Job Mix Formula</td>
<td>Various</td>
<td>For each job mix formula approval</td>
<td>Contractor</td>
</tr>
<tr>
<td>[3.3]</td>
<td>Reclaimed Asphalt Pavement (RAP)</td>
<td>Asphalt Institute MS-2 Mix Design Manual, ASTM D2172</td>
<td>For each job mix formula approval</td>
<td>Contractor</td>
</tr>
<tr>
<td>3.5</td>
<td>Test Section</td>
<td>Various</td>
<td>Approved section prior to start of full production paving</td>
<td>Contractor</td>
</tr>
<tr>
<td>[Marshall: 5.1a(2) &amp; 5.2b(2)]</td>
<td>Stability and Flow</td>
<td>ASTM D6927</td>
<td>One per subplot</td>
<td>DEN Project Manager</td>
</tr>
<tr>
<td>5.1a(2) &amp; 5.2b(1)</td>
<td>Air Voids</td>
<td>ASTM D3203</td>
<td>One per subplot</td>
<td>DEN Project Manager</td>
</tr>
<tr>
<td>5.1a(2) &amp; 5.1b(4)</td>
<td>Bulk Specific Gravity</td>
<td>[ASTM D2726] [ASTM D6752]</td>
<td>One per subplot</td>
<td>DEN Project Manager</td>
</tr>
<tr>
<td>5.1a(2)</td>
<td>Theoretical Maximum Specific Gravity</td>
<td>ASTM D2041</td>
<td>One per subplot</td>
<td>DEN Project Manager</td>
</tr>
<tr>
<td>Specification Reference</td>
<td>Test Type</td>
<td>Test Standard</td>
<td>Minimum Testing Frequency</td>
<td>Responsible Party</td>
</tr>
<tr>
<td>-------------------------</td>
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<td>---------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>5.1b(1) &amp; 5.2b(1)</td>
<td>Mat Density</td>
<td>ASTM D2726</td>
<td>One per subplot</td>
<td>DEN Project Manager</td>
</tr>
<tr>
<td>5.1b(2) &amp; 5.2b(3)</td>
<td>Joint Density</td>
<td>ASTM D2726</td>
<td>One per subplot</td>
<td>DEN Project Manager</td>
</tr>
<tr>
<td>5.2b(4)</td>
<td>Thickness</td>
<td>Not less than ¼ inch deficient from indicated lift thickness, average lift thickness or combined lifts not less than indicated thickness (within grade tolerance)</td>
<td>One per subplot (mat density core)</td>
<td>DEN Project Manager</td>
</tr>
<tr>
<td>5.2b(5)</td>
<td>Smoothness</td>
<td>12-foot straightedge – deviation less 1/4 inch (final surface) [Profiograph per ASTM E1274]</td>
<td>Transverse – continuously across section every 50-feet (minimum) Longitudinally – [center of each paving lane continuously] [ever third point of paving lane] [Profiograph – per lot]</td>
<td>Contractor, in presence of DEN Project Manager</td>
</tr>
<tr>
<td>5.2b(6)</td>
<td>Grade</td>
<td>Less than 0.04 feet</td>
<td>At spot elevations shown on the Paving Plans</td>
<td>Contractor</td>
</tr>
<tr>
<td>6.3a</td>
<td>Asphalt Content</td>
<td>ASTM D6307 or ASTM D2172</td>
<td>Two per lot</td>
<td>Contractor</td>
</tr>
</tbody>
</table>
Table 6
P-401 TESTING SUMMARY

<table>
<thead>
<tr>
<th>Specification Reference</th>
<th>Test Type</th>
<th>Test Standard</th>
<th>Minimum Testing Frequency</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.3b</td>
<td>Gradation</td>
<td>ASTM D5444, ASTM C136, and ASTM C117</td>
<td>Two per lot</td>
<td>Contractor</td>
</tr>
<tr>
<td>6.3c</td>
<td>Moisture Content of Aggregates</td>
<td>ASTM C566</td>
<td>One per lot</td>
<td>Contractor</td>
</tr>
<tr>
<td>6.3d</td>
<td>Moisture Content of HMA</td>
<td>ASTM D1461 [AASHTO T329]</td>
<td>One per lot</td>
<td>Contractor</td>
</tr>
<tr>
<td>6.3e</td>
<td>Temperature</td>
<td>6.3e</td>
<td>Four tests per lot</td>
<td>Contractor</td>
</tr>
<tr>
<td>6.3f</td>
<td>In-Place Density Monitoring (mat and joint)</td>
<td>ASTM D2950</td>
<td>As needed for QC monitoring</td>
<td>Contractor</td>
</tr>
<tr>
<td>6.5</td>
<td>Voids in the Mineral Aggregate (VMA)</td>
<td>-</td>
<td>One per sublot</td>
<td>Contractor</td>
</tr>
</tbody>
</table>

METHOD OF MEASUREMENT

401-7.1 MEASUREMENT. HMA shall be measured by the number of tons of HMA used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage.

BASIS OF PAYMENT

401-8.1 PAYMENT. Payment for a lot of HMA meeting all acceptance criteria as specified in paragraph 401-5.2 shall be made based on results of tests for [smoothness,] mat density and air voids. Payment for acceptable lots shall be adjusted according to paragraph 401-8.1a for mat density and air voids and 401-8.1c for smoothness, subject to the limitation that:
a. The total project payment for plant mix bituminous concrete pavement shall not exceed [ ] percent of the product of the contract unit price and the total number of tons (kg) of HMA used in the accepted work (See Note 1 under Table 6).

b. 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.

Any waste leaving the project site in trucks will be deducted from the total measured tonnage. Both Quality Assurance and Quality Control representatives will agree, on a daily basis, as to the amount of material that is considered waste.

c. Basis of Adjusted Payment. The pay factor for each individual lot shall be calculated in accordance with Table 6. A pay factor shall be calculated for both mat density and air voids. The lot pay factor shall be the higher of the two values when calculations for both mat density and air voids are 100% or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either mat density or air voids is 100% or higher. The lot pay factor shall be the lower of the two values when calculations for both mat density and air voids are less than 100%. If PWL for joint density is less than 71 percent then the lot pay factor shall be reduced by 5% but be no higher than 95%.

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 401-8.1. Payment in excess of 100% for accepted lots of HMA shall be used to offset payment for accepted lots of bituminous concrete pavement that achieve a lot pay factor less than 100%.

Table 6. Price Adjustment Schedule

<table>
<thead>
<tr>
<th>Percentage of material within specification limits (PWL)</th>
<th>Lot pay factor (percent of contract unit price)</th>
</tr>
</thead>
<tbody>
<tr>
<td>96 – 100</td>
<td>106</td>
</tr>
<tr>
<td>90 – 95</td>
<td>PWL + 10</td>
</tr>
<tr>
<td>75 – 89</td>
<td>0.5 PWL + 55</td>
</tr>
<tr>
<td>55 – 74</td>
<td>1.4 PWL – 12</td>
</tr>
<tr>
<td>Below 55</td>
<td>Reject ²</td>
</tr>
</tbody>
</table>
d. Profilograph Smoothness. When the final average profile index (subsequent to any required corrective action) does not exceed 7 inches per mile (18 cm per 1.6 km), payment will be made at the contract unit price for the completed pavement. If the final average profile index (subsequent to any required corrective action) exceeds 7 inches per mile (18 cm per 1.6 km), but does not exceed 15 inches per mile (38 cm per 1.6 m), the Contractor may elect to accept a contract unit price adjustment in lieu of reducing the profile index.

e. Basis of Adjusted Payment for Smoothness. Price adjustment for pavement smoothness will be made in accordance with Table 7. The adjustment will apply to the total tonnage of HMA within a lot of pavement and shall be applied with the following equation:

\[(\text{Tons of asphalt concrete in lot}) \times (\text{lot pay factor}) \times (\text{unit price per ton}) \times (\text{smoothness pay factor}) = \text{payment for lot}\]

Table 7. Profilograph Average Profile Index Smoothness Pay Factor

<table>
<thead>
<tr>
<th>Inches/miles per 1/10 mile</th>
<th>Short Sections</th>
<th>Pay Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 - 7</td>
<td>00.0 - 15.0</td>
<td>100%</td>
</tr>
<tr>
<td>7.1 - 9</td>
<td>15.1 - 16</td>
<td>98%</td>
</tr>
<tr>
<td>9.1 - 11</td>
<td>16.1 - 17</td>
<td>96%</td>
</tr>
<tr>
<td>11.1 - 13</td>
<td>17.1 - 18</td>
<td>94%</td>
</tr>
<tr>
<td>13.1 - 14</td>
<td>18.1 - 20</td>
<td>92%</td>
</tr>
<tr>
<td>14.1 - 15</td>
<td>20.1 - 22</td>
<td>90%</td>
</tr>
<tr>
<td>15.1 and up</td>
<td>22.1 and up</td>
<td>Corrective work required(^1)</td>
</tr>
</tbody>
</table>

\(^1\) The Contractor shall correct pavement areas not meeting these tolerances by removing and replacing the defective work. If the Contractor elects to construct an overlay to correct deficiencies, the minimum thickness of the overlay should be
f. **Payment.** Payment will be made under:

Item P-401-8.1.1 Bituminous [Surface] [Base] [Binder] [Leveling] Course - per ton (kg)

**TESTING REQUIREMENTS**

- **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 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 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 D979** Standard Practice for Sampling Bituminous Paving Mixtures
- **ASTM D1073** Standard Specification for Fine Aggregate for Bituminous Paving Mixtures
- **ASTM D2172** Standard Test Method for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
<table>
<thead>
<tr>
<th>Standard Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D1461</td>
<td>Standard Test Method for Moisture or Volatile Distillates in Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D2041</td>
<td>Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D2489</td>
<td>Standard Practice for Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures</td>
</tr>
<tr>
<td>ASTM D2726</td>
<td>Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures</td>
</tr>
<tr>
<td>ASTM D2950</td>
<td>Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods</td>
</tr>
<tr>
<td>ASTM D3203</td>
<td>Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D3665</td>
<td>Standard Practice for Random Sampling of Construction Materials</td>
</tr>
<tr>
<td>ASTM D3666</td>
<td>Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials</td>
</tr>
<tr>
<td>ASTM D4791</td>
<td>Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate</td>
</tr>
<tr>
<td>ASTM D4867</td>
<td>Standard Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D5444</td>
<td>Standard Test Method for Mechanical Size Analysis of Extracted Aggregate</td>
</tr>
<tr>
<td>ASTM D6307</td>
<td>Standard Test Method for Asphalt Content of Hot Mix Asphalt by Ignition Method</td>
</tr>
<tr>
<td>ASTM D6926</td>
<td>Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus</td>
</tr>
<tr>
<td>[ ]</td>
<td>Standard Practice for Rapid Drying of Compacted Asphalt Specimens Using Vacuum Drying Apparatus</td>
</tr>
</tbody>
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TECHNICAL SPECIFICATIONS
DIVISION 2 – AIRFIELD STANDARDS
ITEM P-401 HOT MIX ASPHALT (HMA) PAVEMENTS

ASTM E11 Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves
ASTM E178 Standard Practice for Dealing with Outlying Observations
ASTM E1274 Standard Test Method for Measuring Pavement Roughness Using a Profilograph
AASHTO T030 Standard Method of Test for Mechanical Analysis of Extracted Aggregate
AASHTO T110 Standard Method of Test for Moisture or Volatile Distillates in Hot Mix Asphalt (HMA)
AASHTO T275 Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens
AASHTO T329 Standard Method of Test for Moisture Content of Hot Mix Asphalt (HMA) by Oven Method

Asphalt Institute Handbook MS-26, Asphalt Binder
Asphalt Institute MS-2 Mix Design Manual, 7th Edition
CDOT CP43 Colorado Department of Transportation Procedure for Determining Moisture (Water) or Volatile Distillates Content of HMA

MATERIAL REQUIREMENTS

ASTM D946 Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D4552 Standard Practice for Classifying Hot-Mix Recycling Agents
ASTM D6373 Standard Specification for Performance Graded Asphalt Binder

END OF ITEM P-401
ITEM P-404 ASPHALT TREATED PERMEABLE BASE

DESCRIPTION

404-1.1 This item shall consist of the construction of an asphalt-treated permeable base (ATPB) course under shoulder pavements, composed of mineral aggregate and bituminous material 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

404-2.1 AGGREGATE. Aggregates shall consist of crushed stone or crushed gravel with or without sand or other inert finely divided mineral aggregate. The portion of materials retained on the No. 4 sieve shall be known as the coarse aggregate. The portion passing the No. 4 sieve and retained on the No. 200 sieve shall be known as the fine aggregate, and the portion passing the No. 200 sieve as mineral filler.

a. Coarse Aggregate. Coarse aggregate shall consist of sound, tough, durable particles, free from coatings of clay, organic matter and other deleterious substances that would prevent thorough coating with the bituminous material. The percentage of wear shall not be greater than 40 percent when tested in accordance with ASTM C 131 (aggregates below 1 1/2 inches). The sodium sulfate soundness loss shall not exceed 20 percent, or the magnesium sulfate soundness loss shall not exceed 13 percent, after five cycles, when tested in accordance with ASTM C 88.

The source of coarse aggregate shall be from quarried rock or river gravel. No slag shall be permitted. All aggregates shall have demonstrated a satisfactory service record of at least 10 years duration under similar conditions of service and exposure.

Aggregate shall contain at least 90 percent by weight of crushed pieces having two or more fractured faces and 85 percent by weight having at least one fractured face. The area of each face shall be equal to at least 75 percent 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. Fractured faces shall be obtained by artificial crushing.

The aggregate shall not contain more than a total of 8 percent, by weight, of flat particles, elongated particles, and flat and elongated particles, when tested in accordance with ASTM D 4791 with a total value of 5:1.
b. **Fine Aggregate.** Fine aggregate shall consist of clean, sound, durable, angular particles produced by crushing stone or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter and shall contain no clay balls.

The fine aggregate, including any blended filler for the fine aggregate, shall have a plasticity index of not more than six and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318.

Natural (non-manufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification.

The percentage of natural sand (not manufactured by crushing) shall be kept below 15 percent to obtain optimum pavement properties as the addition of natural sand tends to decrease stability of pavement. If used, the natural sand shall meet the requirements of ASTM D 1073 and shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASMT D 4318.

The aggregate shall have sand equivalent values of 30 or greater when tested in accordance with ASTM D 2419.

c. **Sampling and Testing.** ASTM D 75 shall be used in sampling course aggregate and ASTM C 183 shall be used in sampling mineral filler. All aggregate samples required for testing shall be furnished by the Contractor and tested by an independent certified laboratory chosen by the Contractor and approved by the DEN Project Manager. No aggregate shall be used in the production of mixtures without prior approval.

404-2.2 **BITUMINOUS MATERIAL.** Bituminous material shall conform to the following requirements:

- Type and Grade Asphalt Cement: PG 64-22
- Specification: ASTM D 3381, Table 2

A mixing temperature for the bituminous material shall be established where the viscosity is between 150 and 300 centistokes. A tolerance of plus or minus 15°F (9°C) will be permitted if the application of these tolerances to the mixing temperature maintains the viscosity between 150 and 300 centistokes. In no case will mixing be permitted at a temperature of less than 275°F (135°C) or greater than 325°F (163°C).

The Contractor shall furnish vendor's certified test reports for each tankload of bitumen shipped to the project. The report shall be delivered to the DEN Project Manager before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall be the basis for final acceptance.

404-2.3 **ANTI-STRIPPING AGENT.** Hydrated lime shall be added at a minimum dosage rate of 0.5 percent by weight of the aggregate. The amount of hydrated lime used
shall be sufficient to produce a coated area above 95 percent and added to the mix design by an approved method.

**COMPOSITION**

404-3.1 **COMPOSITION OF MIXTURE.** The bituminous plant mix shall be composed of a mixture of aggregate 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.

404-3.2 **JOB MIX FORMULA.** No bituminous mixture for payment shall be produced until a job mix formula has been approved by the DEN Project Manager. The formula shall be submitted in writing by the Contractor to the DEN Project Manager at least 10 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 test data 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 DEN Project Manager. Should a change in sources of materials be made, a new job mix formula must be established before the new material is used.

For the ATPB, the bituminous mixture shall be a combination of aggregate and bituminous material conforming to the gradation and bitumen content limits specified in Table 1.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage by Weight Passing Sieves</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 inch</td>
<td>100</td>
</tr>
<tr>
<td>1 inch</td>
<td>95-100</td>
</tr>
<tr>
<td>1/2-inch</td>
<td>25-60</td>
</tr>
<tr>
<td>No. 4</td>
<td>0-10</td>
</tr>
<tr>
<td>No. 8</td>
<td>0-5</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-2</td>
</tr>
<tr>
<td>Bitumen Content</td>
<td>2.0 - 3.5 percent</td>
</tr>
</tbody>
</table>

The Contractor shall establish the percent of bitumen to be used in the ATPB based on the results of his tests of aggregate and based on the observed performance and plant and field tests on the ATPB during the test section specified hereinafter. Further, the DEN Project Manager reserves the right to vary the percent of bitumen of all bituminous mixtures during production as necessary to provide for full coating of all aggregate particles yet provide
minimum drain down of bitumen. The bitumen content may be adjusted within the limits of Table 1 without adjustments in the Contract unit price.

The Contractor shall use an approved heat-stable anti-stripping additive. The anti-stripping additive shall meet the approval of the DEN Project Manager based on the results of laboratory tests. The additive shall be added to the asphalt tank at the recommended dosage (0.5 to 1.0 percent by weight of asphalt cement) and shall be thoroughly mixed by circulation of the asphalt for at least 4 hours prior to being incorporated into the mix. The exact amount of additive to be used shall be determined based on laboratory tests and submitted with the mix design.

The job mix tolerances shown in Table 2 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 based on Table 1, except the upper three sieve sizes in each column shall be within the master band.

<table>
<thead>
<tr>
<th>Material</th>
<th>Tolerance- plus or minus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate passing No. 4 sieve or larger</td>
<td>7 percent</td>
</tr>
<tr>
<td>Aggregate passing No. 8 and 16 sieves</td>
<td>6 percent</td>
</tr>
<tr>
<td>Aggregate passing No. 30 and 50 sieves</td>
<td>5 percent</td>
</tr>
<tr>
<td>Aggregate Passing No. 100 and 200 sieves</td>
<td>3 percent</td>
</tr>
<tr>
<td>Bitumen Content (Individual Tests)</td>
<td>0.45 percent</td>
</tr>
<tr>
<td>Bitumen Content (Moving average of last 5)</td>
<td>0.25 percent variation</td>
</tr>
<tr>
<td>Temperature of mix</td>
<td>20°F (6°C)</td>
</tr>
</tbody>
</table>

The aggregate gradation may be adjusted within the limits of Table 2 as directed, without adjustments in the contract unit prices.

Deviation from the final approved design for bitumen content and gradation of aggregates shall not be greater than the tolerances permitted and shall be based on daily plant extraction. Should a change in sources of materials be made, a new job mix formula shall be established before the new material is used and a new test section shall be required.

**404-3.3 JOB MIX FORMULA (JMF) LABORATORY.** The Contractor’s laboratory used to develop the JMF shall be accredited in accordance with ASTM D3666. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for developing the JMF must be listed on the lab accreditation. Accreditation shall include all test procedures required to develop the mix design. A
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MATERIALS

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The percentage of natural sand (not manufactured by crushing) shall be kept below 15 percent to obtain optimum pavement properties as the addition of natural sand tends to decrease stability of pavement. If used, the natural sand shall meet the requirements of ASTM D 1073 and shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASMT D 4318.

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The Contractor shall use an approved heat-stable anti-stripping additive. The anti-stripping additive shall meet the approval of the DEN Project Manager based on the results of laboratory tests. The additive shall be added to the asphalt tank at the recommended dosage (0.5 to 1.0 percent by weight of asphalt cement) and shall be thoroughly mixed by circulation of the asphalt for at least 4 hours prior to being incorporated into the mix. The exact amount of additive to be used shall be determined based on laboratory tests and submitted with the mix design.

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The aggregate gradation may be adjusted within the limits of Table 2 as directed, without adjustments in the contract unit prices.

Deviation from the final approved design for bitumen content and gradation of aggregates shall not be greater than the tolerances permitted and shall be based on daily plant extraction. Should a change in sources of materials be made, a new job mix formula shall be established before the new material is used and a new test section shall be required.

404-3.3 **JOB MIX FORMULA (JMF) LABORATORY.** The Contractor’s laboratory used to develop the JMF shall be accredited in accordance with ASTM D3666. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for developing the JMF must be listed on the lab accreditation. Accreditation shall include all test procedures required to develop the mix design. A
certification signed by the manager of the laboratory stating it meets these requirements shall be submitted to the DEN Project Manager. The certification shall contain as a minimum:

   a. Qualifications of personnel; including the laboratory manager, supervising technician, and testing technicians.

   b. Evidence of accreditation by a nationally recognized laboratory accreditation organization for all test methods used in developing the asphalt-treated permeable base job mix formula.

404-3.4 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 be sufficient to construct a test section 100 feet (30 m) long by 10 feet (3 m) wide 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.

For the ATPB, plant material and field cores will be taken to perform aggregate gradation, bitumen content, permeability, and temperature. Density and Marshall Stability Tests need not be performed. In no case will the plant-produced mix be considered acceptable if the mix properties of the test section do not meet the requirements of the mix design criteria.

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 in an area of little or no traffic 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 DEN Project Manager’s approval. Test sections will be paid for in accordance with Section 404-7.1.

QUALITY CONTROL

404-4.1 GENERAL. The Contractor will provide and maintain a quality control system that will require the Contractor to provide reasonable assurance that all materials and completed construction submitted for acceptance conform to the Contract requirements whether manufactured or processed by the Contractor, or procured from subcontractors or vendors.

A job mix shall be required by Section 404-3.2 of this specification prior to start of production, and whenever a change in materials warrants retesting.

404-4.2 QUALITY CONTROL DEFICIENCIES. The Contractor shall take prompt action to correct any errors, equipment malfunction, process changes, or other assignable
certification signed by the manager of the laboratory stating it meets these requirements shall be submitted to the DEN Project Manager. The certification shall contain as a minimum:

   a. Qualifications of personnel; including the laboratory manager, supervising technician, and testing technicians.

   b. Evidence of accreditation by a nationally recognized laboratory accreditation organization for all test methods used in developing the asphalt-treated permeable base job mix formula.

404-3.4 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 be sufficient to construct a test section 100 feet (30 m) long by 10 feet (3 m) wide 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.

For the ATPB, plant material and field cores will be taken to perform aggregate gradation, bitumen content, permeability, and temperature. Density and Marshall Stability Tests need not be performed. In no case will the plant-produced mix be considered acceptable if the mix properties of the test section do not meet the requirements of the mix design criteria.

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 in an area of little or no traffic 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 DEN Project Manager’s approval. Test sections will be paid for in accordance with Section 404-7.1.

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A job mix shall be required by Section 404-3.2 of this specification prior to start of production, and whenever a change in materials warrants retesting.

404-4.2 QUALITY CONTROL DEFICIENCIES. The Contractor shall take prompt action to correct any errors, equipment malfunction, process changes, or other assignable
causes which have resulted or could result in submission of materials and completed construction which do not conform to the requirements of the specifications.

404-4.3 TOLERANCES. After the job mix formula is approved, the Contractor shall control the aggregate gradations, the percent bitumen, and the mix temperature within the tolerances specified herein. Failure to meet the control tolerances will be cause to suspend production until the Contractor has identified and corrected the operation to within the job mix tolerances. Continued production without correction may result in rejection and removal of the material.

404-4.4 TESTING LABORATORY. The Contractor or Producer shall provide a testing laboratory to perform all quality control tests necessary to control the production and construction processes applicable to these specifications and as set forth in the Quality Control program. The laboratory performing the testing shall meet the requirements of Section 014525 including ASTM D 3666 accreditation and have been approved through the submittal process prior to performing testing.

404-4.5 QUALITY CONTROL TESTING. Extraction tests for bitumen content and aggregate gradation will be made at least twice daily. Sample aggregate for gradation in accordance with ASTM D 979 or D 75, as applicable. The mixture will be tested for bitumen content in strict conformance with ASTM D 2172, D 4125, or D 6307. If methods D 2172 or D 6307 are used, test aggregate for gradation in accordance with ASTM D 5444. If method D 4125 is used, test aggregate for gradation in accordance with ASTM C 136 and C 117.

CONSTRUCTION METHODS

404-5.1 WEATHER LIMITATIONS. The bituminous mixture shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 3. The temperature requirements may be waived, but only at the discretion of the DEN Project Manager.

<table>
<thead>
<tr>
<th>Mat Thickness</th>
<th>Base Temperature (Minimum) degrees F</th>
<th>Base Temperature (Minimum) degrees C</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inches or greater</td>
<td>40</td>
<td>4</td>
</tr>
<tr>
<td>Greater than 1 inch but less than 3 inches</td>
<td>45</td>
<td>7</td>
</tr>
<tr>
<td>1 inch or less</td>
<td>50</td>
<td>10</td>
</tr>
</tbody>
</table>

a. Other limitations. The excavation of this material is temperature and light sensitive. Due to this, methods of trenching and placing conduit shall be developed.
404-5.2 BITUMINOUS MIXING PLANT. Plants used for the preparation of bituminous mixtures shall conform to the requirements of American Association of State Highway and Transportation Officials (AASHTO) M 156 with the following changes:

a. Requirements for All Plants.

(1) Truck Scales. The bituminous mixture shall be weighed on approved scales furnished by the Contractor, or on public scales at the Contractor's expense. Such scales shall be inspected and sealed as often as the DEN Project Manager deems necessary to assure their accuracy. Scales shall conform to the requirements of the Section 012025 Measurement For Payment.

In lieu of scales, and as approved by the DEN Project Manager, HMA weight may be determined by the use of an electronic weighing system equipped with an automatic printer that weighs the total HMA production and as often thereafter as requested by the DEN Project Manager.

(2) Inspection of Plant. The DEN Project Manager, or his/her authorized representative, shall have access, at all times, to all parts of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and character of materials; and checking the temperatures maintained in the preparation of the mixtures.

(3) Storage Bins and Surge Bins. The ATPB stored in storage bins shall meet the same requirements as ATPB loaded directly into trucks and may be permitted under the following conditions:

(a) The bituminous mixture may be stored in surge bins as directed by the DEN Project Manager for period of time not to exceed 3 hours,

(b) The bituminous mixture may NOT be stored in insulated storage bins.

404-5.3 TRUCKS. Trucks used for hauling bituminous mixtures shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. 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 and covers shall be securely fastened.

404-5.4 BITUMINOUS PAVERS. Bituminous pavers shall be self-contained, power-propelled units with an activated screed or strike off assembly, heated if necessary, and shall be capable spreading and finishing courses of bituminous plant mix material which will meet the specified thickness, smoothness, and grade. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of bituminous plant mix material in widths shown on the Plans.
The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed. The screed or strike off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

The paver shall be capable of operating at forward speeds consistent with satisfactory laying of the mixture.

The paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices that will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within ±0.1%.

The controls shall be capable of working in conjunction with any of the following attachments:

a. Ski type device of not less than 30 feet (9.14 m) in length or as directed by the DEN Project Manager.

b. Taut stringline (wire) set to grade

c. Short ski or shoe

d. Laser control

404-5.5 ROLLERS. An approved steel wheel roller, weighing not less than 8 tons or more than 12 tons and having a unit compression on the drive wheels of not less than 250 (113 kg) nor more than 400 pounds (181 kg) per inch (cm) of roller width, shall be used to compact the mix. Vibratory rollers meeting the above requirements may be used to compact the ATPB provided the vibratory unit is turned off. Rollers shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition.

The use of equipment which causes excessive crushing of the aggregate will not be permitted.

404-5.6 PREPARATION OF BITUMINOUS MATERIAL. The bituminous material shall be heated in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature. The temperature of the bituminous material delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles but shall not exceed 325°F (160°C).
404-5.7  **PREPARATION OF MINERAL AGGREGATE.** The aggregate for the mixture shall be dried and heated to the temperature designated by the job formula within the job tolerance specified. The maximum temperature and rate of heating shall be such that no permanent damage occurs to the aggregates. 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.

404-5.8  **PREPARATION OF BITUMINOUS MIXTURE.** The aggregates and the bituminous material shall be weighed or metered and introduced into the mixer in the amount specified by the job mix formula.

The combined materials shall be mixed until the aggregate obtains a uniform coating of bitumen and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture. It shall be established by the Contractor, based on the procedure for determining the percentage of coated particles described in ASTM D 2489, and approved by the DEN Project Manager for each individual plant and for each type of aggregate used. The minimum mixing time shall be 25 seconds. The mixing time will be set to achieve 95 percent of coated particles. For continuous mix plants, the minimum 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 the mix shall not exceed 1.0 percent.

404-5.9  **TRANSPORTING, SPREADING, AND FINISHING.** The mixture shall be transported from the mixing plant to the point of use in vehicles conforming to the requirements of Section 404-5.3. Deliveries shall be scheduled so that spreading and rolling of all mixture prepared for 1 day's run can be completed during daylight, unless adequate artificial lighting is provided. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

Immediately before placing the bituminous mixture, the underlying course shall be cleared of all debris with power blowers, power brooms, or hand brooms as directed.

The mix shall be placed at a temperature of not less than 250 °F (107°C). In addition, the ATPB shall be spread only when the atmospheric temperature is above 40°F (4°C).

Upon arrival, the ATPB shall be spread to the full width by an approved bituminous paver. The ATPB shall be placed and compacted in a single layer thickness of 6 inches (15 cm) and will conform to the grade and contour indicated on the Plans. Automatic grade control shall be used for placement of the permeable base. Grade control shall be wire or string reference lines for elevation and alignment. When string lines are required, they shall consist of piano wire or other approved material. The string lines shall be supported at a minimum of 25 foot (7.6 m) centers. Additional supports shall be installed to prevent sag, if required. The horizontal alignment of the string lines shall be within plus or minus 1/4 inch (6 mm) per 10 feet (3 m). The Contractor shall provide a satisfactory method of securing the string line where vertical curves are constructed to maintain the proper grade.
After the first lane is constructed, the joint matcher (short ski) shall be used on the previously laid lane. The free edge shall be controlled as specified herein before. The automatic transverse grade control device shall be used only when one paving lane of each side of the high point of the pavement is to be constructed. Example: One lane pavement or two lane crowned pavement.

The control system shall be automatically actuated from the reference line through a system of mechanical sensors or sensor directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise directed, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of 12 feet (3.7 m) except where edge lanes require less width to complete the area. 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 mixture may be spread, raked, and luted by hand tools.

404-5.10 COMPACtion of mixture. After spreading, the mixture shall be thoroughly and uniformly compacted by rolling. The surface shall be rolled when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. Rolling of the ATPB shall begin when the temperature of the mixture is less than 150°F (66°C) and shall be completed before the mixture is less than 100°F (38°C). 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. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once. To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but excessive water will not be permitted. Water shall not be used to cool the mixture.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until all roller marks are eliminated, the surface is of uniform texture and true to grade and cross section, and the required field density from the test section evaluation is obtained. In areas not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers.

Rolling shall be by three complete coverages of the specified static roller. The DEN Project Manager reserves the right to increase or decrease the specified number of roller coverages and the specified temperature limits for rolling during construction based on test data and observed performance from the test section or production placement of the ATPB.

Any mixture that becomes loose and broken, mixed with dirt, 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.

404-5.11 JOINTS. The formation of all joints shall be made in such a manner as to ensure a continuous bond between old and new sections of the course. All joints shall have the same texture, density, and smoothness as other sections of the course.

The roller shall not pass over the unprotected end of the freshly laid mixture 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, in which case the edge shall be cut back to its full depth and width on a straight line to expose a vertical face. In both methods, all contact surfaces shall be given a tack coat of bituminous material before placing any fresh mixture against the joint.

Longitudinal joints which are irregular, damaged, or otherwise detective shall be cut back to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be given a tack coat of bituminous material prior to placing any fresh mixture against the joint.

404-5.12 SURFACE TESTS. Tests for conformity with the specified crown and grade shall be made by the Contractor immediately after initial compaction. Any variation shall be corrected by the removal or addition of materials and by continuous rolling as described in this section. Tabular summary of straight edge records and location will be given to the DEN Project Manager.

After the ATPB has been compacted, the surface shall be tested by the Contractor and furnished to the DEN Project Manager for smoothness and conformance to the elevations shown on the Plans. The finished surface shall not vary more than 3/8 inch from the surface course when tested with a 16 foot (4.8 m) straightedge applied parallel with and at right angles to the centerline, nor more than plus zero to minus 1/2 inch from the elevations shown on the Plans. This tolerance shall be maintained prior to the installation of the edge light cans.

ATPB with a surface higher than design elevation or with a surface variation exceeding the specified tolerances shall be removed and replaced with ATPB which complies with these specifications. If approved by the DEN Project Manager, the high spots may be removed to within specified tolerance by any method that does not produce contaminating fines nor damage the ATPB to remain in place. Grinding shall not be permitted.

Hardened ATPB with a surface lower than 1/2 inch below elevations shown shall be removed and replaced with ATPB which complies with these specifications. If approved by the DEN Project Manager, the low areas may be filled with bituminous course conforming to the requirements for the overlaying course. This shall be done as a separate operation prior to placement of the overlying course. No additional compensation will be allowed for additional bituminous course depth resulting from ATPB elevations being too low.

404-5.13 ACCEPTANCE. ATPB shall be accepted on the following requirements:
a. Material properties conforming to the JMF per the quality control testing in section 404-4.5.

b. The evaluated surface tests in section 404-5.12

c. The visual inspection and observations by the DEN Project Manager to determine if the required number of rolling passes have achieved compaction without the crushing of aggregates.

404-5.14 PROTECTION OF ATPB. Care shall be exercised to prevent contamination or damage to previously completed ATPB. The Contractor will only place an amount of ATPB that can be covered by the overlying course in a reasonable amount of time.

Construction equipment other than hauling and paving equipment necessary for placement of the overlying course and electrical installation shall not operate on the finished ATPB. Route and operate material hauling trucks and other equipment in a manner to minimize the amount of mud and dirt carried onto the ATPB. If necessary, clean equipment of mud and dirt prior to operation on the ATPB. The Contractor has the option to construct any electrical items directly on the ATPB or after the placement of the first lift of asphalt base course.

Operate equipment in a manner to prevent damage to the completed ATPB. Equipment shall avoid rapid acceleration, hard braking, or sharp turning.

Any ATPB which, in the opinion of the DEN Project Manager, has become contaminated or damaged shall be removed and replaced by the Contractor with ATPB which conforms to these specification requirements, at the Contractor's sole expense.

METHOD OF MEASUREMENT

404-6.1 Asphalt Treated Permeable Base (ATPB) Course shall be measured by the number of square yards as specified in-place, complete and accepted by the DEN Project Manager.

BASIS OF PAYMENT

404-7.1 Payment for accepted Asphalt Treated Permeable Base (ATPB) Course shall be made at the full or adjusted contract unit price per square yard. This price shall be full 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.

Item P-404-5.1 Asphalt Treated Permeable Base Course (5-7 Inches) – Per Square Yard

TESTING REQUIREMENTS

ASTM C 29 Unit Weight of Aggregate
TECHNICAL SPECIFICATIONS

DIVISION 2 – AIRFIELD STANDARDS

ITEM P-404 ASPHALT TREATED PERMEABLE BASE

DENVER INTERNATIONAL AIRPORT

2017 ANNUAL AIRFIELD PAVEMENT REHABILITATION

CONTRACT NO. 201733182

ASTM C 88 Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 131 Resistance to Abrasion of Small Size Course Aggregate by Use of the Los Angeles Machine
ASTM C 136 Sieve or Screen Analysis of Fine and Course Aggregates
ASTM C 183 Sampling Hydraulic Cement
ASTM D 75 Sampling Aggregates
ASTM D 1075 Effect of Water on Cohesion of Compacted Bituminous Mixtures
ASTM D 1188 Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin Coated Specimens
ASTM D 2172 Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2489 Degree of Particle Coating of Bituminous Aggregate Mixtures
ASTM D 2726 Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimens
ASTM D 3665 Random Sampling of Paving Materials
ASTM D 3666 Inspection and Testing Agencies for Bituminous Paving Materials
ASTM D 4125 Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D 4318 Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 6307 Asphalt Content of Hot-Mix Asphalt by the Ignition Method
AASHTO T 30 Mechanical Analysis of Extracted Aggregate
MS-2 Mix Design Methods for Asphalt Concrete

MATERIAL REQUIREMENTS

ASTM D 242 Mineral Filler for Bituminous Paving Mixtures
ASTM D 946 Asphalt Cement for Use in Pavement Construction
ASTM D 3381 Viscosity Graded Asphalt Cement for Use in Pavement Construction

END OF ITEM P-404
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 550 lb / square inch (3.8 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.

   a. General. New pavement slabs that are broken or contain cracks or are otherwise defective or unacceptable shall be removed and replaced or repaired, as directed by the DEN Project Manager and as specified hereinafter at no cost to the Owner. Spalls along joints shall be repaired as specified. 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 DEN Project 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 4 inch (100 mm) diameter, shall be drilled by the Contractor and shall be filled by the Contractor with a well consolidated concrete mixture bonded to the walls of the hole with epoxy resin, using approved procedures. Drilling of cores and refilling holes shall be at no expense to the Owner. All epoxy resin used in this work shall conform to ASTM C881, Type V. Repair of cracks as described in this section shall not be allowed if in the opinion of the DEN Project 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.

   b. Shrinkage cracks. Shrinkage cracks, which do not exceed 4 inches (100 mm) in depth, shall be cleaned and then pressure injected with epoxy resin, Type IV, Grade 1, using procedures as approved by the DEN Project Manager. Care shall be taken to assure that the crack is not widened during epoxy resin injection. All epoxy resin injection shall take place in the presence of the DEN Project Manager. Shrinkage cracks, which exceed 4 inches (100 mm) in depth, shall be treated as full depth cracks in accordance with paragraphs 4.19b and 4.19c.

   c. 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 4 inches (100 mm) in depth, that extend into the interior area.

   d. Cracks close to and parallel to joints. All cracks essentially parallel to original joints, extending full depth of the slab, and lying wholly within 6 inches (150 mm)
either side of the joint shall be treated as specified here. Any crack extending more than 6 inches (150 mm) from the joint shall be treated as specified above in subparagraph c.

(1) **Full depth cracks present, original joint not opened.** When the original un-cracked joint has not opened, the crack shall be sawed and sealed, and the original joint filled with epoxy resin as specified below. The crack shall be sawed with equipment specially designed to follow random cracks. The reservoir for joint sealant in the crack shall be formed by sawing to a depth of 3/4 inches (19 mm), ±1/16 inch (2 mm), and to a width of 5/8 inch (16 mm), ±1/8 inch (3 mm). Any equipment or procedure which causes raveling or spalling along the crack shall be modified or replaced to prevent such raveling or spalling. The joint sealant shall be a liquid sealant as specified. Installation of joint seal shall be as specified for sealing joints or as directed. If the 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. If filler type material has been used to form a weakened plane in the transverse joint, it shall be completely sawed out and the saw cut 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 present, original joint also cracked.** At a joint, 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 for the full lane width and length.

e. **Removal and replacement of full slabs.** Where it is necessary to remove full slabs, unless there are dowels present, all edges of the slab shall be cut full depth with a concrete saw. All saw cuts shall be perpendicular to the slab surface. If dowels, or tie bars are present along any edges, these edges shall be sawed full depth just beyond the end of the dowels or tie bars. These joints shall then be carefully sawed on the joint line to within one inch (25 mm) of the depth of the dowel or tie bar.

The main slab shall be further divided by sawing full depth, at appropriate locations, and each piece lifted out and removed. Suitable equipment shall be used to provide a truly vertical lift, and approved safe lifting devices used for attachment to the slabs. The narrow strips along doweled edges shall be carefully broken up and removed using light, hand-held jackhammers, 30 lb (14 kg) or less, or other approved similar equipment.

Care shall be taken to prevent damage to the dowels, tie bars, or to concrete to remain in place. The joint face below dowels shall be suitably trimmed so that there is not abrupt offset in any direction greater than 1/2 inch (12 mm) and no gradual offset greater than one inch (25 mm) when tested in a horizontal direction with a 12-foot (3.7-m) straightedge.
No mechanical impact breakers, other than the above hand-held equipment shall be used for any removal of slabs. If underbreak between 1-1/2 and 4 inches (38 and 100 mm) deep occurs at any point along any edge, the area shall be repaired as directed before replacing the removed slab. Procedures directed will be similar to those specified for surface spalls, modified as necessary.

If underbreak over 4 inches (100 mm) deep occurs, the entire slab containing the underbreak shall be removed and replaced. Where there are no dowels or tie bars, or where they have been damaged, dowels or tie bars of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified. Original damaged dowels or tie bars shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All four (4) edges of the new slab shall contain dowels or original tie bars.

Placement of concrete shall be as specified for original construction. Prior to placement of new concrete, the underlying material (unless it is stabilized) shall be re-compacted and shaped as specified in the appropriate section of these specifications. The surfaces of all four joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels or tie bars. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

f. Repairing Spalls Along Joints. Where directed, spalls along joints of new slabs, and along parallel cracks used as replacement joints, shall be repaired by first making a vertical saw cut at least one inch (25 mm) outside the spalled area and to a depth of at least 4 inches (100 mm). Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and at least 1/2 inch (12 mm) of visually sound concrete. The cavity thus formed shall be thoroughly cleaned by sandblasting to remove all loose material. Immediately before filling the cavity, a prime coat of epoxy resin, Type III, Grade I, shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Pooling of epoxy resin shall be avoided. The cavity shall be filled with an appropriate spall repair material from the CDOT Approved Products List (APL). The spall repair material shall be approved by the DEN Project Manager prior to installation. Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the DEN Project Manager. The epoxy resin materials shall be placed in the cavity in layers not over 2 inches (50 mm) thick. The time interval between placement of additional layers shall be such that the temperature of the epoxy resin material does not exceed 140°F (60°C) at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the material. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints, or as required to be routed for cracks. The reservoir shall be thoroughly cleaned and sealed with the sealer specified for the joints.
If any spall penetrates half the depth of the slab or more, the entire slab shall be removed and replaced as previously specified. If any spall would require over 25% of the length of any single joint to be repaired, the entire slab shall be removed and replaced. Repair of spalls as described in this section shall not be allowed if in the opinion of the DEN Project Manager the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of spalls shall be allowed in any panel that demonstrates segregated aggregate with a significant absence of coarse aggregate in the upper one-eighth (1/8th) inch of the pavement surface.

**g. Diamond grinding of PCC surfaces.** Diamond grinding of the hardened concrete with an approved diamond grinding machine should not be performed until the concrete has reached minimum strength specified in Paragraph 501-4.8. When required, diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the pavement. The saw blades shall be 1/8-inch (3-mm) wide and there shall be a minimum of 55 to 60 blades per 12 inches (300 mm) of cutting head width; the actual number of blades will be determined by the Contractor and depend on the hardness of the aggregate. The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130 inches wide. The peaks and ridges shall be approximately 1/32 inch higher than the bottom of the grooves. Each machine shall be capable of cutting a path at least 3 feet (0.9 m) wide. Equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints will not be permitted. The area corrected by diamond grinding the surface of the hardened concrete should not exceed 10% of the total area of any sublot. 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. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. All pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified shall be removed and replaced in conformance with Paragraph 501-4.19. The pavement shall be left in a clean condition. The removal of all of the slurry resulting from the grinding operation shall be continuous. The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement.

**h. Weak Surfaces.** Weak surfaces are defined as mortar-rich, rain damaged, uncurved, or containing exposed voids or deleterious materials. Weak surfaces are considered defective. The corrective action shall be as determined by the DEN Project Manager.

**501-4.20 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR.**

All operations shall be carefully controlled to prevent damage to the concrete pavement and to the underlying material to remain in place. All saw cuts shall be made perpendicular to the slab surface.

**a. Removal of existing pavement slab.**
When it is necessary to remove existing concrete pavement and leave adjacent concrete in place, [unless there are dowels present,] the joint between the removal area and adjoining pavement to stay in place. [including dowels or tie bars,] shall first be cut full depth with a standard diamond-type concrete saw. [If dowels are present at this joint, the saw cut shall be made full depth just beyond the end of dowels. The edge shall then be carefully sawed on the joint line to within one inch (25 mm) of the top of the dowel.] Next, a full depth saw cut shall be made parallel to the joint at least 24 inches (600 mm) from the joint and at least 12 inches (300 mm) from the end of any dowels. All pavement between this last saw cut and the joint line shall be carefully broken up and removed using hand-held jackhammers, 30 lb (14 kg) or less, or the approved light-duty equipment which will not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. [Where dowels are present, care shall be taken to produce an even, vertical joint face below the dowels. If the Contractor is unable to produce such a joint face, or if underbreak or other distress occurs, the Contractor shall saw the dowels flush with the joint. The Contractor shall then install new dowels, of the size and spacing used for other similar joints, by epoxy resin bonding them in holes drilled in the joint face as specified in paragraph 501-4.10g. All this shall be at no additional cost to the Owner.] [Dowels of the size and spacing indicated shall be installed as shown on the drawings by epoxy resin bonding them in holes drilled in the joint face as specified in paragraph 501-4.10g.] The joint face shall be sawed or otherwise trimmed so that there is no abrupt offset in any direction greater than 1/2 inches (12 mm) and no gradual offset greater than one inch (25 mm) when tested in a horizontal direction with a 12-foot (3.7-m) straightedge.

b. Edge Repair.

The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Areas that are damaged during construction shall be repaired at no cost to the Owner.

(1) Spall repair. Spalls shall be repaired where indicated and where directed by the DEN Project Manager. Repair materials and procedures shall be as previously specified in subparagraph 501-4.19f.

(2) Underbreak repair. All underbreak shall be repaired. First, all delaminated and loose material shall be carefully removed. Next, the underlying material shall be recompacted, without addition of any new material. Finally, the void shall be completely filled with paving concrete, thoroughly consolidated. Care shall be taken to produce an even joint face from top to bottom. Prior to placing concrete, the underlying material shall be thoroughly moistened. After placement, the exposed surface shall be heavily coated with curing compound.

(3) Underlying material. The underlying material adjacent to the edge and under the existing pavement which is to remain in place shall be protected from damage or disturbance during removal operations and until placement of new concrete, and shall be shaped as shown on the drawings or as directed. Sufficient material shall be kept in place outside the joint line to prevent disturbance (or sloughing) of material under the pavement.
that is to remain in place. Any material under the portion of the concrete pavement to remain in place, which is disturbed or loses its compaction shall be carefully removed and replaced with concrete as specified in paragraph 501-4.20b(2). The underlying material outside the joint line shall be thoroughly compacted and moist when new concrete is placed.

**MATERIAL ACCEPTANCE**

**501-5.1 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 Engineer at no cost to the Contractor. The Contractor shall bear the cost of coring and filling operations, per paragraph 501-5.1b(1). Curing facilities will be provided by the Owner. Testing organizations performing these tests 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 acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory’s current accreditation and accredited test methods shall be submitted to the DEN Project Manager prior to start of construction.

A Pre-Work meeting will be held with the Contractor, Quality Control Lab, Quality Acceptance, and the DEN Project Manager to discuss the sampling and testing of the flexural strength specimens. The meeting shall include, but not be limited to, procedures for sampling, fabrication, handling, initial and final curing, and strength testing.

Concrete shall be accepted for strength and thickness on a lot basis.

A lot shall consist of a day’s production not to exceed 2,000 cubic yards (1530 cubic meters) [[ square yards (square meters)].

a. **Flexural Strength.**

(1) **Sampling.** Each lot shall be divided into four equal sublots. One sample shall be taken for each subplot from the plastic concrete delivered to the job site. Sampling locations shall be determined by the DEN Project Manager in accordance with random sampling procedures contained in ASTM D3665. The concrete shall be sampled in accordance with ASTM C172.

(2) **Testing.** Three (3) flexural strength specimens shall be made from each sample. The flexural strength specimens shall be fabricated in steel molds in accordance with ASTM C 31. If the flexural strength specimens are initially cured in the field, they shall be transported to the laboratory (for final curing and testing) while in the molds. The flexural strength specimens shall be standard cured including storage, initial curing, and final curing (for beams) in accordance with ASTM C 31 and tested for flexural strength in accordance with ASTM C 78. The flexural strength for each subplot shall be computed by averaging the results of the two test specimens representing that subplot. If a specimen tests abnormally low in strength indicating possible damage to that specimen, the hold specimen shall be tested and its results used in the average. Slump, air content, unit weight, and temperature tests in accordance with ASTM C 143, C 231, C 138 and C 1064.
will also be conducted by the quality assurance laboratory for each set of flexural strength test samples.

(3) Acceptance. Acceptance of pavement for flexural strength will be determined by the DEN Project Manager in accordance with paragraph 501-5.2b.

b. Pavement Thickness.

(1) Sampling. Each lot shall be divided into four equal sublots and one core shall be taken by the Contractor for each sublot. Sampling locations shall be determined by the DEN Project Manager in accordance with random sampling procedures contained in ASTM D3665. Areas, such as thickened edges, with planned variable thickness, shall be excluded from sample locations.

Cores shall be neatly cut with a core drill. The Contractor shall furnish all tools, labor, and materials for cutting samples and filling the cored hole. Core holes shall be filled by the Contractor with a non-shrink grout approved by the DEN Project Manager within one day after sampling.

(2) Testing. The length of the cores shall be determined by the DEN Project Manager by the average caliper measurement in accordance with ASTM C174.

(3) Acceptance. Acceptance of pavement for thickness shall be determined by the DEN Project Manager in accordance with paragraph 501-5.2c.

c. Partial Lots. When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and DEN Project Manager agree in writing to allow 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 shall constitute a lot. Where one or two sublots have been produced, they shall be incorporated into the next lot or the previous lot and the total number of sublots shall be used in the acceptance criteria calculation, that is, n=5 or n=6.

d. Outliers. All individual flexural strength tests within a lot shall be checked for an outlier (test criterion) in accordance with ASTM E178, at a significance level of 5%. Outliers shall be discarded, and the percentage of material within specification limits (PWL) shall be determined using the remaining test values.

501-5.2 ACCEPTANCE CRITERIA.

a. General. Acceptance will be based on the following characteristics of the completed pavement discussed in paragraph 501-5.2e:

(1) Flexural strength
TECHNICAL SPECIFICATIONS

(2) Thickness
(3) Smoothness
(4) Grade
(5) Edge slump

Flexural strength and thickness shall be evaluated for acceptance on a lot basis using the method of estimating PWL. Acceptance using PWL considers the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results to calculate the percentage of material that is above the lower specification tolerance limit (L).

Acceptance for flexural strength will be based on the criteria contained in accordance with paragraph 501-5.2e(1). Acceptance for thickness will be based on the criteria contained in paragraph 501-5.2e(2). Acceptance for smoothness will be based on the criteria contained in paragraph 501-5.2e(3). Acceptance for grade will be based on the criteria contained in paragraph 501-5.2e(4).

The DEN Project 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 DEN Project Manager, and if it can be demonstrated in the laboratory, in the presence of the DEN Project Manager, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

b. Flexural strength. Acceptance of each lot of in-place pavement for flexural strength shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher.

c. Pavement thickness. Acceptance of each lot of in-place pavement shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher.

d. Percentage of material within limits (PWL). The PWL shall be determined in accordance with procedures specified in Section 110 of the General Provisions.

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

<table>
<thead>
<tr>
<th>Lower Specification Tolerance Limit (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural Strength</td>
</tr>
<tr>
<td>Thickness</td>
</tr>
</tbody>
</table>

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

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

(3) **Smoothness.** As soon as the concrete has hardened sufficiently, but not later than 48 hours after placement, the surface of each lot shall be tested in both longitudinal and transverse directions for smoothness to reveal all surface irregularities exceeding the tolerances specified. The Contractor shall furnish paving equipment and employ methods that produce a surface for each section of pavement having an average profile index meeting the requirements of paragraph 501-8.1c when evaluated with a profilograph; and the finished surface of the pavement shall not vary more than 1/4 inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. When the surface smoothness exceeds specification tolerances which cannot be corrected by diamond grinding of the pavement, full depth removal and replacement of pavement shall be to the limit of the longitudinal placement. Corrections involving diamond grinding will be subject to the final pavement thickness tolerances specified.

(a) **Transverse measurements.** Transverse measurements will be taken for each lot placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50 feet (15m) or more often as determined by the DEN Project Manager.

i) Testing shall be continuous across all joints, starting with one-half the length of the straight edge at the edge of pavement section being tested and then moved ahead one-half the length of the straight edge for each successive measurement. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. The amount of 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 these two high points. Deviations on final pavement > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 501-4.19g or by removing and replacing full depth of pavement. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding. Each measurement shall be recorded and a copy of the data shall be furnished to the DEN Project Manager at the end of each days testing.

ii) The joint between lots shall be tested separately to facilitate smoothness between lots. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface, with half the straightedge on one side of the joint and the other half of the straightedge on the other side of...
the joint. Measure the maximum gap between the straightedge and the pavement surface in the area between these two high points. One measurement shall be taken at the joint every 50 feet (15m) or more often if directed by the DEN Project Manager. Maximum gap on final pavement surface > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 501-4.19g or by removing and replacing full depth of surface. Each measurement shall be recorded and a copy of the data shall be furnished to the DEN Project Manager at the end of each days testing. Each measurement shall be recorded and a copy of the data shall be furnished to the DEN Project Manager at the end of each days testing.

(b) Longitudinal measurements. Longitudinal measurements will be taken for each lot 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 (6m); and at the one third points of paving lanes when widths of paving lanes are 20 ft (6m) or greater.

i) Longitudinal Short Sections. Longitudinal Short Sections are when the longitudinal lot length is less than 200 feet (60m) and areas not requiring a profilograph. When approved by the DEN Project Manager, the first and last 15 feet (4.5m) of the lot can also be considered as short sections for smoothness. The finished surface shall not vary more than 1/4 inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. Smoothness readings will not be made across grade changes or cross slope transitions, at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. Testing shall be continuous across all joints, starting with one-half the length of the straight edge at the edge of pavement section being tested and then moved ahead one-half the length of the straight edge for each successive measurement. The amount of 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 these two high points. Deviations on final pavement surface > 1/4 inch (6mm) in longitudinal direction will be corrected with diamond grinding per paragraph 501-4.19g or by removing and replacing full depth of surface. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

ii) Profilograph Testing. Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2 inch (5 mm) blanking band. The bump template must span one inch (25 mm) with an offset of 0.4 inches (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved operator. Profilograms shall be recorded on a longitudinal scale of one inch (25 mm) equals 25 feet (7.5 m) and a vertical scale of one inch (25 mm) equals one inch (25 mm). A copy of the reduced tapes shall be furnished to the DEN Project Manager at the end of each days testing.
The pavement must have an average profile index meeting the requirements of paragraph 501-8.1c. Deviations on final surface in longitudinal direction shall be corrected with diamond grinding per paragraph 501-4.19g or by removing and replacing full depth of pavement. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

Where corrections are necessary, second profilograph runs shall be performed to verify that the corrections produced an average profile index of 15 inches (38 cm) per mile or less. If the initial average profile index was less than 15 inches (38 cm), only those areas representing greater than 0.4 inch (10 mm) deviation will be re-profiled for correction verification.

iii) Final Profilograph of [Runway]. Final profilograph, full length of runway, shall be performed to facilitate testing of smoothness between lots. Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The pavement must have an average profile index meeting the requirements of paragraph 501-8.1c. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2 inch (5 mm) blanking band. The bump template must span one inch (25 mm) with an offset of 0.4 inches (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved, trained operator. Profilograms shall be recorded on a longitudinal scale of one inch (25 mm) equals 25 feet (7.5 m) and a vertical scale of one inch (25 mm) equals one inch (25 mm). A copy of the reduced tapes shall be furnished to the DEN Project Manager at the end of each days testing. Profilograph of final runway shall be performed one foot right and left of runway centerline and 15 feet right and left of centerline. Any areas that indicate “must grind” will be corrected as directed by the DEN Project Manager.

Two passes shall be made in each paving lane 20 feet or greater in width; each pass shall be six feet from and parallel with the centerline of the paving lane. The average of the two passes shall be considered as the profilograph result for the paving lane. For paving lanes less than 20 feet in width, one pass along the centerline shall be required. Tests shall be run the next working day following concrete placement. Runs shall be continuous through the days production. Each trace shall be completely labeled to show paving lane, wheel pass, and stationing.

Smoothness testing indicated in the above paragraphs except paragraph (iii) shall be performed within 48 hours of placement of material. Smoothness testing indicated in paragraph (iii) shall be performed within 48 hours final paving completion. The primary purpose of smoothness testing is to identify areas that may be prone to ponding of water which could lead to hydroplaning of aircraft. If the contractor’s machines and/or methods are producing significant areas that need corrective actions then production should be stopped until corrective measures can be implemented. If corrective measures are not implemented and when directed by the DEN Project Manager, production shall be stopped until corrective measures can be implemented.
(4) **Grade.** An evaluation of the surface grade shall be made by the DEN Project Manager for compliance to the tolerances contained below. The finished grade of each lot will be determined by running levels at all joint intersections to determine the alignment and elevation of the completed pavement. Vertical survey shall be conducted on the high point of each joint intersection and compared to the plan elevations to determine the vertical deviation. The Contractor shall pay the cost of surveying and the surveying shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the DEN Project Manager.

When the grade exceeds specification tolerances which cannot be corrected by diamond grinding, full depth removal and replacement of pavement shall be to the limit of the pavement that allows for grade correction in accordance with Section 501-4.19. Corrections involving diamond grinding will be subject to the final pavement thickness tolerances specified. Patching shall not be permitted.

Grade shall be evaluated on the first day of placement and then every 5 days or less, so adjustments can be made to paving operations if measurements do not meet specification requirements. The contractor must submit the survey data to the DEN Project Manager by the following day after measurements have been taken. The DEN Project Manager must compare the surveyed grades with the grades shown on the contract drawings and document the analysis.

(a) **Lateral deviation.** Lateral deviation from established alignment of the pavement edge shall not exceed ±0.10 feet (30 mm) in any lane.

(b) **Vertical deviation.** Vertical deviation from established grade shall not exceed ±0.04 feet (12 mm) at any point.

When more than 15 percent of all the measurements within a lot are outside the specified tolerance, or if any one shot within the lot deviates ¾ inch or more from planned grade, the Contractor shall remove and replace the deficient slabs to the full width, length and depth of the slab. Patching shall not be permitted. Isolated high points may be ground off provided that the course thickness is not greater than ¼ inch deficient in the design thickness.

(5) **Edge slump.** When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive edge slump shall be removed and replaced at the expense of the Contractor as directed by the DEN Project Manager in accordance with paragraph 501-4.8a.

f. **Removal and replacement of concrete.** Any area or section of concrete that is removed and replaced shall be removed and replaced back to planned joints. The Contractor shall replace damaged dowels and the requirements for doweled longitudinal construction joints in paragraph 501-4.10 shall apply to all contraction joints exposed by concrete removal. Removal and replacement shall be in accordance with paragraph 501-4.20.

**CONTRACTOR QUALITY CONTROL**
501-6.1 QUALITY CONTROL PROGRAM. The Contractor shall develop a Quality Control Program in accordance with Section 100 of the General Provisions. The program shall address all elements that affect the quality of the pavement including but not limited to:

a. Mix Design

b. Aggregate Gradation

c. Quality of Materials

d. Stockpile Management

e. Proportioning

f. Mixing and Transportation

g. Placing and Consolidation

h. Joints

i. Dowel Placement and Alignment

j. Flexural or Compressive Strength

k. Finishing and Curing

l. Surface Smoothness

501-6.2 QUALITY CONTROL TESTING. The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to this specification and as set forth in the Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for aggregate gradation, aggregate moisture content, slump, and air content.

A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

The Independent Testing Agency shall meet the requirements of Section 01401 including ASTM C 1077.

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.

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.

c. Slump. After the start of each day’s production and after batch plant shut down, the first three truckloads of concrete shall be tested for slump until three consecutive loads meet the project requirements. In addition, slump tests shall be performed at a minimum frequency of one test for every 100 cubic yards. Slump tests shall also be performed in conjunction with the DEN Project Manager’s Quality Assurance Lab’s sampling for flexural strength. The samples shall be obtained in accordance with ASTM C172 from material discharged from trucks at the paving site and tested in accordance with ASTM C143.

d. Air Content. After the start of each day’s production and after batch plant shut down, the first three truckloads of concrete shall be tested for air content until three consecutive loads meet the project requirements. In addition, air content tests shall be performed at a minimum frequency of one test for every 100 cubic yards. Air content tests shall also be performed in conjunction with the DEN Project Manager’s Quality Assurance Lab’s sampling for flexural strength. The samples shall be obtained in accordance with ASTM C172 from material discharged from trucks at the paving site and tested in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag or other porous coarse aggregate.

e. Unit weight and yield tests shall be made in conjunction with slump and air content tests. The samples shall be obtained in accordance with ASTM C172 from material discharged from trucks at the paving site and tested in accordance with ASTM C138.

501-6.3 CONTROL CHARTS. The Contractor shall maintain linear control charts for fine and coarse aggregate gradation, slump, moisture content and air content.

Control charts shall be posted in a location satisfactory to the DEN Project 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 DEN Project 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. Specification limits contained in the Lower Specification Tolerance Limit (L) table above and the Control Chart Limits table below shall be superimposed on the Control Chart for job control.

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 of 2 consecutive tests) for slump and air content in accordance with the following Action and Suspension Limits.

<table>
<thead>
<tr>
<th>Control Parameter</th>
<th>Individual Measurements</th>
<th>Range Suspension Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Action Limit</td>
<td>Suspension Limit</td>
</tr>
<tr>
<td>Slip Form:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slump</td>
<td>+0 to -1 inch (0-25 mm)</td>
<td>+0.5 to -1.5 inch (13-38 mm)</td>
</tr>
<tr>
<td>Air Content</td>
<td>±1.2%</td>
<td>±1.8%</td>
</tr>
<tr>
<td>Side Form:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slump</td>
<td>+0.5 to -1 inch (13-25 mm)</td>
<td>+1 to -1.5 inch (25-38 mm)</td>
</tr>
<tr>
<td>Air Content</td>
<td>±1.5%</td>
<td>±1.8%</td>
</tr>
</tbody>
</table>

The individual measurement control charts shall use the mix design target values as indicators of central tendency.

501-6.4 **CORRECTIVE ACTION.** The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of control. The Contractor Quality Control Program 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 specification limits in paragraph 501-2.1, immediate steps, including a halt to production, shall be taken to correct the grading.
b. **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.

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

(1) One point falls outside the Action Limit line for individual measurements. The next load shall be tested. If its test falls outside the Action and Suspension Limits this load may be placed however; production is in Suspension and the process shall be brought into control in accordance with the Quality Control Plan. As a minimum testing during Suspension shall be performed at both the batch plant and at the point of placement until three (3) subsequent loads in succession meet the slump specifications at the point of placement. Any load not meeting slump specifications under Suspension shall not be placed.

OR

(2) One point falls outside the Suspension Limit line for individual measurements or range. This load may remain in place. The process shall be brought into control in accordance with the Quality Control Plan. As a minimum testing during Suspension shall be performed at both the batch plant and at the point of placement until three (3) subsequent loads in succession meet the slump specifications at the point of placement. Any load not meeting slump specifications under Suspension shall not be placed.

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

(1) One point falls outside the Action Limit line for individual measurements, the next load shall be tested. If its test falls outside the Action and Suspension Limit this load may be placed however; production is in Suspension and the process shall be brought into control in accordance with the Quality Control Plan. As a minimum testing during Suspension shall be performed at both the batch plant and at the point of placement until three (3) subsequent loads in succession meet the air content specifications at the point of placement. Any load not meeting air content specifications under Suspension shall not be placed one point falls outside the Suspension Limit line for individual measurements or range

OR

(2) One point falls outside the Suspension Limit line for individual measurements or range. This load may remain in place. The process shall be brought into control in accordance with the Quality Control Plan. As a minimum testing during Suspension shall be performed at both the batch plant and at the point of placement until three (3) subsequent loads in succession meet the air content specifications at the point of placement. Any load not meeting air content specifications under Suspension shall not be placed two points in a row fall outside the Action Limit line for individual measurements.
Whenever a point falls outside the Action Limits line, the air-entraining admixture dispenser shall be calibrated to ensure that it is operating correctly and with good reproducibility.

**METHOD OF MEASUREMENT**

501-7.1 Portland cement concrete pavement shall be measured by the number of [cubic yards (cubic meters)] [square yards (square meters)] of either plain or reinforced pavement as specified in-place, completed and accepted.

**BASIS OF PAYMENT**

501-8.1 **PAYMENT.** Payment for concrete pavement meeting all acceptance criteria as specified in paragraph 501-5.2 Acceptance Criteria shall be based on results of [smoothness,] 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 and 501-8.1c for smoothness, subject to the limitation that:

The total project payment for concrete pavement shall not exceed [ ] percent of the product of the contract unit price and the total number of [cubic yards (cubic meters)] [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 flexural strength and thickness. The lot pay factor shall be the higher of the two values when calculations for both flexural 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 flexural strength or thickness is 100% or higher. The lot pay factor shall be the lower of the two values when calculations for both flexural strength and thickness are less than 100%.

<table>
<thead>
<tr>
<th>Percentage of Materials Within Specification Limits (PWL)</th>
<th>Lot Pay Factor (Percent of Contract Unit Price)</th>
</tr>
</thead>
<tbody>
<tr>
<td>96 – 100</td>
<td>106</td>
</tr>
<tr>
<td>90 – 95</td>
<td>PWL + 10</td>
</tr>
<tr>
<td>75 – 90</td>
<td>0.5 PWL + 55</td>
</tr>
<tr>
<td>55 – 74</td>
<td>1.4 PWL – 12</td>
</tr>
</tbody>
</table>

1 Basis of adjusted payment.
Percentage of Materials Within Specification Limits (PWL) | Lot Pay Factor (Percent of Contract Unit Price)
--- | ---
Below 55 | Reject²

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. However, if the DEN Project Manager and the FAA have decided to allow the rejected lot to remain in accordance with Section 50-02 after the DEN Project Manager and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50% of the contract unit price and the total project payment limitation shall be reduced by the amount withheld for the rejected 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%.

b. Payment. Payment shall be made under:

Item P-501-8.1a Portland Cement Concrete Pavement – [per cubic yard (cubic meter)] [per square yard (square meter)]

c. Basis of adjusted payment for smoothness. Price adjustment for pavement smoothness will apply to the total area of concrete within a section of pavement and shall be applied in accordance the following equation and schedule:

\[(\text{Square yard in section}) \times (\text{original unit price per square yard}) \times P_{Fm} = \text{reduction in payment for area within section}\]

<table>
<thead>
<tr>
<th>Average Profile Index (Inches Per Mile)</th>
<th>Contract Unit Price Adjustment (P_{Fm})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement Strength Rating</td>
<td>Over 30,000 lb</td>
</tr>
<tr>
<td>Over 30,000 lb</td>
<td>0 - 7</td>
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<tr>
<td>0 - 7</td>
<td>0.00</td>
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<tr>
<td>7.1 - 9</td>
<td>0.02</td>
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<tr>
<td>9.1 - 11</td>
<td>0.04</td>
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<tr>
<td>11.1 - 13</td>
<td>0.06</td>
</tr>
<tr>
<td>13.1 - 14</td>
<td>0.08</td>
</tr>
<tr>
<td>Average Profile Index (Inches Per Mile)</td>
<td>Contract Unit Price Adjustment</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Pavement Strength Rating</td>
<td>(PFm)</td>
</tr>
<tr>
<td>Over 30,000 lb</td>
<td></td>
</tr>
<tr>
<td>14.1 - 15</td>
<td></td>
</tr>
<tr>
<td>30,000 lb or Less</td>
<td></td>
</tr>
<tr>
<td>15.1 and up</td>
<td></td>
</tr>
<tr>
<td>Short Sections</td>
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</tr>
<tr>
<td>20.1 - 22</td>
<td>0.10</td>
</tr>
<tr>
<td>22.1 and up</td>
<td>Corrective work required</td>
</tr>
</tbody>
</table>

**TESTING REQUIREMENTS**

- **ASTM C31**: Standard Practice for Making and Curing Concrete Test Specimens in the Field
- **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 C117**: Standard Test Method for Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing
- **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 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
MATERIAL REQUIREMENTS

U.S. Army Corps of Engineers (USACE) Concrete Research Division (CRD) C662 Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)
TECHNICAL SPECIFICATIONS

DENVER INTERNATIONAL AIRPORT

DIVISION 2 – AIRFIELD STANDARDS

2017 ANNUAL AIRFIELD PAVEMENT REHABILITATION

ITEM P-501 PORTLAND CEMENT CONCRETE (PCC) PAVEMENT

2017 ANNUAL AIRFIELD PAVEMENT REHABILITATION

CONTRACT NO. 201733182

MARCH 2017

REVISION NO. [REV #]

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 A714 Standard Specification for High-Strength Low-Alloy Welded and Seamless Steel Pipe

ASTM A775 Standard Specification for Epoxy-Coated Steel Reinforcing Bars

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 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 C33 Standard Specification for Concrete Aggregates

ASTM C94 Standard Specification for Ready-Mixed Concrete

ASTM C150 Standard Specification for Portland Cement

ASTM C171 Standard Specification for Sheet Materials for Curing Concrete

ASTM C260 Standard Specification for Air-Entraining Admixtures for Concrete

ASTM C309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

ASTM C494 Standard Specification for Chemical Admixtures for Concrete

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 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 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

ACI 211.1  Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete

ACI 305R  Guide to Hot Weather Concreting

ACI 306R  Guide to Cold Weather Concreting

ACI 309R  Guide for Consolidation of Concrete

AC 150/5320-6  Airport Pavement Design and Evaluation

PCA  Design and Control of Concrete Mixtures

END ITEM P-501
ITEM P-603 BITUMINOUS TACK COAT

DESCRIPTION

603-1.1 This item shall consist of preparing and treating a bituminous or concrete surface with bituminous material in accordance with these specifications and in reasonably close conformity to the lines shown on the plans.

MATERIALS

603-2.1 BITUMINOUS MATERIALS. The bituminous material shall be an emulsified asphalt indicated in ASTM D3628 as a bituminous application for tack coat appropriate to local conditions or as designated by the DEN Project Manager.

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 DEN Project Manager.

603-3.2 EQUIPMENT. The Contractor shall provide equipment for heating and applying the bituminous 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 bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard (0.23 to 9.05 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 ±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 bituminous material manually to areas inaccessible to the distributor. Equip the distributor to circulate and agitate the bituminous material during the heating process. If the distributor is not equipped with an operable quick shutoff valve, the tack operations shall be started and stopped on building paper. The Contractor shall remove blotting sand prior to asphalt concrete lay down operations at no additional expense to the Owner.
A power broom and/or power blower suitable for cleaning the surfaces to which the bituminous tack coat is to be applied shall be provided.

603-3.3 APPLICATION OF BITUMINOUS MATERIAL. Immediately before applying the 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.

Emulsified asphalt shall be diluted by the addition of water when directed by the DEN Project Manager and shall be applied a sufficient time in advance of the paver to ensure that all water has evaporated before the overlying mixture is placed on the tacked surface.

The bituminous material including vehicle shall be uniformly applied with a bituminous distributor at the rate of 0.05 to 0.10 gallons per square yard (0.20 to 0.50 liters per square meter) depending on the condition of the existing surface. The type of bituminous material and application rate shall be approved by the DEN Project Manager prior to application.

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 DEN Project Manager. The Contractor shall protect the tack coat and maintain the surface until the next course has been placed.

603-3.4 BITUMINOUS MATERIAL CONTRACTOR’S RESPONSIBILITY. The Contractor shall provide a statement of source and character of the proposed bituminous material which must be submitted and approved by the DEN Project Manager before any shipment of bituminous materials to the project.

The Contractor shall furnish the vendor’s certified test reports for each carload, or equivalent, of bituminous material shipped to the project. The DEN Project Manager may use the local state DOT agency supplier certification program for approval instead of the test reports. The tests reports shall be provided to and approved by the DEN Project Manager before the bituminous material is applied. If the bituminous material does not meet the specifications, it shall be replaced at the Contractor’s expense. Furnishing the vendor’s certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. Samples may be taken and tested for verification by the DEN Project Manager when material is delivered to the site.

603-3.5 FREIGHT AND WEIGH BILLS. The Contractor shall submit waybills and delivery tickets, during progress of the work. Before the final statement is allowed, file with the DEN Project Manager certified waybills and certified delivery tickets for all bituminous materials used in the construction of the pavement covered by the contract. Do not remove bituminous 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 or payment for tack coat. The work under this item shall be considered subsidiary to other items of work.

**BASIS OF PAYMENT**

603-5.1 Bituminous tack coat shall be considered incidental to the project. No payment shall be made for bituminous tack coat.

**MATERIAL REQUIREMENTS**

- ASTM D633  Standard Volume Correction Table for Road Tar
- ASTM D977  Standard Specification for Emulsified Asphalt
- ASTM D2028 Standard Specification for Cutback Asphalt (Rapid-Curing Type)
- ASTM D2397 Standard Specification for Cationic Emulsified Asphalt
- ASTM D3628 Standard Practice for Selection and Use of Emulsified Asphalts

**END ITEM P-603**
ITEM P-604A PREFORMED EXPANSION JOINT COMPRESSION SEALS

DESCRIPTION

604A-1.1 This item shall consist of a moisture tight sealing system for structural sealing of expansion joints in concrete pavement. The seal shall consist of an impermeable closed-cell, closed link, ethylene vinyl acetate, low-density polyethylene copolymer, nitrogen blown resilient, nonextrudable foam material with a Ultraviolet (UV) stabilizer added.

MATERIALS

604A-2.1 GENERAL. The material shall be meet the following physical requirements in Table 1. The material must be jet fuel resistant, glycol compatible, and include a UV stabilizer.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Method</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression Set</td>
<td>ASTM D3575 Suffix B</td>
<td>10% - 2 Hr Recovery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9% - 24 Hr Recovery</td>
</tr>
<tr>
<td>Elongation at break</td>
<td>ASTM D3575 Suffix T</td>
<td>185% - 280%</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM D3575 Suffix T</td>
<td>92 - 140 psi (640 -950 KPa)</td>
</tr>
<tr>
<td>Tear Resistance</td>
<td>ASTM D624</td>
<td>10-20 lbs/in (1.79 - 3.57 kg/cm)</td>
</tr>
<tr>
<td>Density</td>
<td>ASTM D3575 Suffix W</td>
<td>2.7 -3.4 lbs/ft³ (43.2 – 54.5 kg/m³)</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>ASTM D3575 Suffix L</td>
<td>0.02 lbs/ft² (0.09 kg/m²)</td>
</tr>
<tr>
<td>Weather/Deterioration</td>
<td>AASHTO T42</td>
<td>No Deterioration</td>
</tr>
</tbody>
</table>

604A-2.2 ADHESIVE. Adhesive used for the preformed foam compression seal shall be as recommended by the manufacturer.

604A-2.3 DELIVERY AND STORAGE. 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 to maintain them at temperatures as recommended by the manufacturer.
604A-2.4 SUBMITTALS. Certified copies of test results shall be provided in accordance with Section 013300 Submittal Procedures and 013325 Shop and Working Drawings, Product Data and Samples.

a. Construction Equipment List. List of proposed equipment to be used in the performance of construction work, including descriptive data, shall be provided in accordance with Section 013300 and Section 013325.

b. Manufacturer's Instructions. Where installation procedures, or any part thereof, are required to be in accordance with the manufacturer's recommendations, printed copies of the recommendations shall be furnished in accordance with Section 013300 and Section 013325. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be a cause for rejection of the material.

c. Test Reports/Samples. The Contractor shall submit certified copies of the test reports and samples of the materials for approval in accordance with Section 013300 and Section 013325. Printed directions from the manufacturer on recommended installation criteria shall be furnished with the test reports, plus the manufacturer’s certification that the selected seal is recommend for the installation on this project. No material will be used until it has been approved by the DEN Project Manager.

EQUIPMENT

604A-3.1 Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and shall be maintained in satisfactory condition at all times.

a. Joint Cleaning Equipment:

(1) Concrete Saw. A self-propelled power saw with water cooled diamond or abrasive 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) Sandblasting Equipment. Sandblasting equipment shall include an air compressor, hose, and a longwearing 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.
(3) **Waterblasting Equipment.** Waterblasting equipment shall include a trailer mounted water tank, pumps, high pressure hose, and a wand with safety release cutoff controls, nozzle, and auxiliary water resupply equipment. The water tank and auxiliary water resupply equipment shall be 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 (13 mm) on either side of the joint. The pump shall be capable of supplying a pressure of at least 3,000 psi (21 MPa). A pressure gauge mounted at the pump shall show at all times the pressure in pounds per square inch (kPa) at which the equipment is operating.

**CONSTRUCTION METHODS**

**604A-4.1 GENERAL.** Installation of foam joint sealant shall comply with Manufacturer’s instructions and recommendations for foam joint sealant installation complete with a compatible epoxy adhesive for adhesion to all surfaces.

Prior to installing foam joint sealant, make sure that surfaces to which adhesive will adhere are clean and free of dust, dirt and other residues that would inhibit a proper bond.

The Contractor shall make arrangements for the Manufacturer’s representative to meet with the Contractor and the DEN Project Manager prior to the start of sealing operations to ensure the installation procedures are in accordance with the Manufacturer’s direction. A representative of the joint sealant manufacturer shall visit the job-site a sufficient number of times during the sealing operations and after the sealing is completed to certify that the joint sealant was installed in accordance with the manufacturer’s recommended methods and procedures.

**604A-4.2 PREPARATION OF JOINTS.** Immediately before installation of the preformed joint seal, the joints shall be thoroughly cleaned full depth to remove all laitance, filler, old existing sealant, foreign material and protrusions of hardened concrete from the sides and upper edges of the joint space to be sealed. Any irregularity in the joint face, which would prevent uniform contact between the joint seal and the joint face shall be corrected prior to the installation of the joint seal. All joint faces shall be vertical.

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 3 calendar days of the time the individual joint cavity is sawed. Depth of sawing the cavity shall be between ¾ (19 mm) and 1 inch (25 mm) deeper than the uncompressed depth of the seal, or otherwise recommended by the manufacturer. 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 plus or minus 1/16 inch (2 mm) or as noted in the details.

b. **Sandblast Cleaning.** The concrete joint faces and pavement surfaces extending at least 1/2 inch (13 mm) from the joint edges shall be sandblasted clean. A
multiple pass technique shall be used until the surfaces are free of dust, direct 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. Waterblast Cleaning. The concrete joint faces and pavement surfaces extending at least 1/2 inch (13 mm) from the joint edges shall be waterblasted clean. A multiple pass technique shall be used until the surfaces are free of dust, direct, curing compound, or any residue that might prevent ready insertion or uniform contact of the seal and bonding of the 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. When waterblast cleaning is used, slurry residue must be removed to provide a relatively dust free concrete surface.

d. Rate of Progress. The stages of joint preparation which includes sandblasting or waterblasting of the joint faces and air pressure cleaning of the joints shall be limited to only the linear footage of joint that can be sealed during the same workday.

604A-4.3 TIME OF INSTALLATION. Joints shall be sealed within 3 calendar days of sawing the joint seal cavity and immediately following concrete cure and the final cleaning of the joint walls. Open joints ready for sealing that cannot be sealed under the conditions specified herein shall be provided with an approved temporary seal to prevent infiltration of foreign material. When rain interrupts the sealing operations, the joints shall be washed, air pressure cleaned and allowed to dry prior to installing the lubricant/adhesive and preformed seal.

604A-4.4 CLEAN UP. Prior to Substantial Completion, all unused materials shall be removed from the site, any adhesive on the pavement surface shall be removed, and the pavement shall be left in clean condition.

604A-4.5 WARRANTY. The Manufacturer shall provide a warranty on the materials furnished for a minimum of 5 years from the date of acceptance by the DEN Project Manager. The Contractor shall provide a warranty on the installation for a minimum of 5 years from the date of acceptance by the DEN Project Manager.

QUALITY CONTROL

604A-5.1 PROCEDURES. Quality control provisions shall be provided during the joint cleaning process to prevent or correct improper equipment and cleaning techniques that damages the concrete in any manner. Cleaned joints shall be approved by the DEN Project Manager prior to installation of the adhesive and preformed joint seal.

604A-5.2 PRODUCT. The joint sealing system (preformed seal) shall be inspected for proper rate of cure and bonding to the concrete, cuts, twists, nicks, and other deficiencies.
Seals exhibiting any defects, at any time prior to final acceptance of the project, shall be removed from the joint, wasted, and replaced in a satisfactory manner.

METHOD OF MEASUREMENT

604A-6.1 There shall be no direct measurement or payment for Preformed Expansion Joint Compression Seals associated with new pavement construction. The work under this item shall be considered incidental to the project.

BASIS OF PAYMENT

604A-7.1 Preformed Expansion Joint Compression Seals associated with new pavement construction shall be considered incidental to the project. No payment shall be made for Preformed Expansion Joint Compression Seals.

TESTING REQUIREMENTS

AASHTO T42 Standard Specification for Preformed Expansion Joint Filler for Concrete Construction

ASTM D 6211 Test Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers

ASTM D 3575 SUFFIX B Flexible Cellular Materials Made from Olefin Polymers
ASTM D 3575 SUFFIX L Flexible Cellular Materials Made from Olefin Polymers
ASTM D 3575 SUFFIX T Flexible Cellular Materials Made from Olefin Polymers
ASTM D 3575 SUFFIX W Flexible Cellular Materials Made from Olefin Polymers

END OF ITEM P-604A
ITEM P-604B POLYCHLOROPRENE COMPRESSION JOINT SEALS

DESCRIPTION

604B-1.1 This item shall consist of preformed polychloroprene compression seals used for sealing joints of rigid pavements.

MATERIALS

604B-2.1 PREFORMED SEALS. Preformed joint seal materials shall be a vulcanized elastomeric compound using polychloroprene as the only base polymer. The material and the manufactured seal itself shall conform to ASTM D 2628 and CRD C 548. The joint seal shall be a labyrinth type seal with the uncompressed depth of the seal greater than the uncompressed width of the seal. The actual width of the uncompressed seal shall be per manufacturer’s recommendation for the widths of joint as shown on the Contract Drawings.

604B-2.2 LUBRICANT/ADHESIVE. Lubricant/adhesive used for the preformed elastomeric joint seal shall be a one component compound conforming to ASTM D 2835.

604B-2.3 DELIVERY AND STORAGE. 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 to maintain them at temperatures as recommended by the manufacturer.

604B-2.4 SUBMITTALS. Certified copies of test results shall be provided in accordance with Section 013300 Submittal Procedures and Section 013325 Shop and Working Drawings, Product Data and Samples.

   a. Construction Equipment List. List of proposed equipment to be used in the performance of construction work, including descriptive data, shall be provided in accordance with Section 013300 and Section 013325.

   b. Manufacturer's Instructions. Where installation procedures, or any part thereof, are required to be in accordance with the manufacturer's recommendations, printed copies of the recommendations shall be furnished in accordance with Section 013300 and Section 013325. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be a cause for rejection of the material.

   c. Test Reports/Samples. The Contractor shall submit certified copies of the test reports and samples of the materials for approval in accordance with Section 013300 and Section 013325. Printed directions from the manufacturer on recommended installation criteria shall be furnished with the test reports, plus the manufacturer’s certification that the
selected seal is recommended for the installation on this project. No material will be used until it has been approved by the DEN Project Manager.

**604B-2.5 TEST REQUIREMENTS.** Each lot of compression joint seal and lubricant/adhesive shall be sampled, identified, and tested for conformance with the applicable material specification. A lot of preformed seal shall consist of one day’s production or 20,000 linear feet (6000 meters) for each cross-section, whichever is less. A lot of lubricant/adhesive shall consist of one day’s production. No material shall be used at the project prior to receipt of written notice that the materials meet the laboratory requirements.

Testing of the preformed joint and lubricant/adhesive material shall be the responsibility of the Contractor and shall be performed in an approved independent laboratory and certified copies of the test reports shall be submitted for approval in accordance with Section 013300 and Section 013325, prior to the use of the materials at the job site. Samples of each lot of material shall also be submitted and will be retained by the DEN Project Manager for possible future testing should the materials appear defective during or after application. The Contractor shall furnish additional samples of materials, in sufficient quantity to be tested, upon request. Final acceptance will be based on conformance to the specified test requirements and the performance of the in-place materials.

**EQUIPMENT**

**604B-3.1** Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and shall be maintained in satisfactory condition at all times.

a. **Joint Cleaning Equipment**

   (1) **Concrete saw.** A self-propelled power saw with water cooled diamond or abrasive 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) **Sandblasting Equipment.** Sandblasting equipment shall include an air compressor, hose, and a longwearing 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 (4 cubic meter) 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.

   (3) **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 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 (13 mm) on either side of the joint. The pump shall be capable of supplying a pressure of at least 3,000 psi (21 MPa). A pressure gauge mounted at the pump shall show at all times the pressure in pounds per square inch (kPa) at which the equipment is operating.

b. Sealing Equipment. Equipment used to install the preformed seal shall place the preformed 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 1.5 percent 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 at all times be operated by an experienced operator.

Single axle type seal application equipment will not be permitted.

CONSTRUCTION METHODS

604B-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 or per manufacturer’s installation procedures. Sealant application will not be permitted if moisture or any foreign material is observed in the joint.

604B-4.2 TRIAL JOINT SEAL AND LUBRICANT/ADHESIVE INSTALLATION. Prior to the cleaning and sealing of the joints for the entire project, a test section at least 200 feet (61 meters) long shall be prepared at a location directed in the project pavement using the specified materials and the approved equipment, so as to demonstrate the proposed joint preparation and sealing of all types of joints in the project. Following the completion of the trial length and before any other joint is sealed; the trial joints will be inspected by the DEN Project Manager and Manufacturer’s representative to determine that the materials and installation meet the requirements specified. If materials or installation do not meet requirements the materials shall be removed, and the joints shall be re-cleaned and resealed at no cost to the owner. No other joints shall be sealed until the test installation has been approved. If the trial section is approved, it may be incorporated into the permanent work. All other joints shall be sealed in the manner approved for sealing the trial joints.

604B-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 be performed using equipment in accordance with paragraph 604B3.1a and 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 completely free of debris and water. Demonstrate that the selected cleaning operation meets the cleanliness requirements. 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 3 calendar days of the time the individual joint cavity is sawed. Depth of sawing the cavity shall be between \(\frac{3}{4}\) (19 mm) and 1 inch (25 mm) deeper than the uncompressed depth of the seal, or otherwise recommended by the manufacturer. 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 plus or minus 1/16 inch (2 mm).

b. **Sandblast Cleaning.** The concrete joint faces and pavement surfaces extending at least 1/2 inch (13 mm) from the joint edges shall be sandblasted clean. A multiple pass technique shall be used until the surfaces are free of dust, direct 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. **Waterblast Cleaning.** The concrete joint faces and pavement surfaces extending at least 1/2 inch (13 mm) from the joint edges shall be waterblasted clean. A multiple pass technique shall be used until the surfaces are free of dust, direct, 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. When waterblast cleaning is used, slurry residue must be removed to provide a relatively dust-free concrete surface.

d. **Rate of Progress.** Sandblasting or waterblasting of the joint faces and air pressure cleaning of the joints shall be limited to the linear footage of joint that can be sealed during the same workday.

**604B-4.4 INSTALLATION OF THE PREFORMED SEAL.**

a. **Time of Installation.** Joints shall be sealed within 3 calendar days of sawing the joint seal cavity and immediately following concrete cure and the final cleaning of the joint walls. Open joints ready for sealing that cannot be sealed under the conditions specified herein shall be provided with an approved temporary seal to prevent infiltration of foreign material. When rain interrupts the sealing operations, the joints shall be washed, air pressure cleaned and allowed to dry prior to installing the lubricant/adhesive and preformed seal.
b. **Sequence of Installation.** Longitudinal joints shall be sealed first, followed by transverse joints and then all other joints. Seals in longitudinal joints shall be cut so that all transverse joint seals will be intact 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. Extender pieces of seal shall not be used at intersections. Any seal falling short of the intersection shall be removed and replaced with new seal at no additional cost to the airport.

**604B-4.5 SEALING OF JOINTS.** The joint seal shall be installed using the equipment specified in paragraph 604B-3.1b. 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 in such a manner as to conform to all requirements specified. Butt joints and seal intersections shall be sealed with sealant recommended by sealant Manufacturer. Lubricant/adhesive/sealant spilled on the pavement shall be removed immediately to prevent setting on the pavement. The in-place joint seal shall be in an upright position and free from twisting, distortion, and cuts.

Adjustments shall be made to the installation equipment and procedure, if the stretch exceeds 1%. Any seal exceeding 2% stretch shall be removed and replaced. The joint seal shall be placed at a uniform depth within the tolerances specified. In-place joint seal which fails to meet the specified requirements shall be removed and replaced with new joint seal in a satisfactory manner at no additional cost to the owner. The preformed joint seal shall be placed to a depth as shown on the Contract Drawings. For chamfered joints or joints with a radius at the surface, the preformed joint seal shall be installed at a depth of 1/8 inch (3 mm), plus or minus 1/8 inch (3 mm), below the bottom of the edge of the chamfer or radius. No part of the seal shall be allowed to project above the surface of the pavement or above the edge of the chamfer or radius. The seal shall be installed in the longest practicable lengths in longitudinal joints and shall be cut at the joint intersections so as to provide continuous installation of the seal in the transverse joints. The lubricant/adhesive in the longitudinal shall be allowed to set for 1 hour prior to cutting at the joint intersections to reduce the possibility of shrinkage. For all transverse joints, the minimum length of the preformed joint seal shall be the pavement width from edge to edge.

**604B-4.6 CLEANUP.** Prior to Substantial Completion, all unused materials shall be removed from the site, any lubricant/adhesive on the pavement surface shall be removed, and the pavement shall be left in clean condition.

**604B-4.7 WARRANTY.** The Manufacturer shall provide a warranty on the materials furnished for a minimum of 5 years from the date of acceptance by the DEN Project Manager. The Contractor shall provide a warranty on the installation for a minimum of 2 years from the date of acceptance by the DEN Project Manager.

**QUALITY CONTROL**

**604B-5.1 QUALITY CONTROL PROVISIONS.**

a. **Equipment.** The application equipment shall be inspected to assure uniform application of lubricant/adhesive to the sides of the preformed joint seal or the walls of the joint. If any equipment causes cutting, twisting, nicking, excessive stretching or compressing
of the preformed seal, or improper application of the lubricant/adhesive the operation shall be suspended until causes of the deficiencies are determined and corrected.

b. Procedures

(1) Quality control provisions shall be provided during the joint cleaning process to prevent or correct improper equipment and cleaning techniques that damage the concrete in any manner. Cleaned joints shall be approved by the DEN Project Manager prior to installation of the lubricant/adhesive and preformed joint seal.

(2) Conformance to stretching and compression limitations shall be determined. After installation, the distance between the marks shall be measured on the pavement. If the stretching or compression exceeds the specified limit, the seal shall be removed and replaced with new joint seal at no additional cost to the owner. The seal shall be removed up to the last correct measurement. The seal shall be inspected a minimum of once per 100 feet (30 m) of seal for compliance to the shrinkage or compression requirements. Measurements shall also be made as directed to determine conformance with depth and width installation requirements. All preformed seal that is not in conformance with specification requirements shall be removed and replaced with new joint seal at no additional cost to the owner.

c. Inspection. The joint sealing system (preformed seal and lubricant/adhesive) shall be inspected by the DEN Project Manager for proper rate of cure and bonding to the concrete, cuts, twists, nicks, and other deficiencies. Seals exhibiting any defects, at any time prior to final acceptance of the project, shall be removed from the joint, wasted, and replaced in a satisfactory manner, as determined by the DEN Project Manager.

METHOD OF MEASUREMENT

604B-6.1 There shall be no direct measurement or payment for Polychloroprene Compression Joint Seals associated with new pavement construction. The work under this item shall be considered incidental to the project.

BASIS OF PAYMENT

604B-7.1 Polychloroprene Compression Joint Seals associated with new pavement construction shall be considered incidental to the project. No payment shall be made for Polychloroprene Compression Joint Seals.

TESTING REQUIREMENTS

U.S. ARMY CORPS OF ENGINEERS

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 2628  Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements

ASTM D 2835  Lubricant for Installation of Preformed Compression Seals in Concrete Pavements.

END OF ITEM P-604B
ITEM P-605 JOINT SEALANTS FOR CONCRETE 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 and cracks in rigid pavements.

MATERIALS

605-2.1 JOINT SEALERS. Joint sealant materials shall meet the requirements of [   ].

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, nonshrinking, non-staining, non-absorbing material that is non-reactive with the joint sealant. The material shall have a water absorption of not more than 5% when tested in accordance with ASTM C509. The backer-rod material shall be 25% ± 5% larger in diameter than the nominal width of the crack.

605-2.3 BACKUP MATERIALS. Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorbing material, nonreactive with the joint sealant. 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 material shall have a water absorption of not more than 5% of the sample weight when tested in accordance with ASTM C509. The backup material shall be 25 ±5% larger in diameter than the nominal width of the crack.

605-2.4 BOND BREAKING TAPES. Provide a bond breaking tape or separating material that is a flexible, nonshrinkable, nonabsorbing, nonstaining, and nonreacting 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.

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, [_____] days prior to use on the project.

a. [Tractor-mounted routing tool. Provide a routing tool, used for removing old sealant from the joints, of such shape and dimensions and so mounted on the tractor that it will not damage the sides of the joints. The tool shall be designed so that it can be adjusted to remove the old material to varying depths as required. The use of V-shaped tools or rotary impact routing devices will not be permitted. Hand-operated spindle routing devices may be used to clean and enlarge random cracks.

b. 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 or for refacing joints or cleaning sawed joints where sandblasting does not provide a clean joint.

c. Sandblasting equipment. [Sandblasting is not allowed.] [Include with the sandblasting equipment an air compressor, hose, and 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 capable of furnishing not less than 150 cfm (71 L/s) and maintaining a line pressure of not less than 90 psi (621 kPa) at the nozzle while in use. Demonstrate compressor capability, under job conditions, before approval. 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 approximately one inch (25 mm) above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to secure satisfactory results.]

d. Waterblasting equipment. Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. Provide water tank and auxiliary resupply equipment of sufficient capacity to permit continuous operations. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately one inch (25 mm) above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to obtain satisfactory results. A pressure gauge mounted at the pump shall show at all times the pressure in psi (kPa) at which the equipment is operating.

e. Hand tools. Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces.
f. 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.

g. Two-component, cold-applied, machine mix sealing equipment. Provide equipment used for proportioning, mixing, and installing Federal Specification SS-S-200 Type M joint sealants designed to deliver two semifluid components through hoses to a portable mixer at a preset ratio of one (1) to one (1) by volume using pumps with an accuracy of ±5% for the quantity of each component. The reservoir for each component shall be equipped with mechanical agitation devices that will maintain the components in a uniform condition without entrapping air. Incorporate provisions to permit thermostatically controlled indirect heating of the components, when required. However, immediately prior to proportioning and mixing, the temperature of either component shall not exceed 90°F (32°C). Provide screens near the top of each reservoir to remove any foreign particles or partially polymerized material that could clog fluid lines or otherwise cause misproportioning or improper mixing of the two components. Provide equipment capable of thoroughly mixing the two components through a range of application rates of 10 to 60 gallons (37.8 to 189 L) per hour and through a range of application pressures from 50 to 1500 psi (345 kPa to 10.3 MPa) as required by material, climatic, or operating conditions. Design the mixer for the easy removal of the supply lines for cleaning and proportioning of the components. The mixing head shall accommodate nozzles of different types and sizes as may be required by various operations. The dimensions of the nozzle shall be such that the nozzle tip 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.

h. Two-component, cold-applied, hand-mix sealing equipment. Mixing equipment for Federal Specification SS-S-200 Type H sealants shall consist of a slow-speed electric drill or air-driven mixer with a stirrer in accordance with the manufacturer’s recommendations. Submit printed copies of manufacturer’s recommendations [_____] days prior to use on the project where installation procedures, or any part thereof, are required to be in accordance with those recommendations. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

i. 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.

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] [tractor-mounted routing equipment] [concrete saw] [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. Back-up material. 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 back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backup material 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-breaker separating tape 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 DEN Project 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 [1/8] [1/4] inch ([3] [6] mm) ±1/16 inch (2 mm) below the pavement surface. 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 Contracting Officer. 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.

605-3.7 FIELD TEST. Before sealing the joints, the Contractor shall demonstrate that the equipment and procedures for preparing, mixing, and placing the sealant will produce a satisfactory joint seal. The demonstration shall include the preparation of at least two small batches and the application of the resulting material in five joints of at least 25 feet in length each. A representative of the joint sealant manufacturer shall be present at the demonstration to ensure that the installation procedures are in accordance with the manufacturer’s recommended installation instructions.

a. Testing For Cold Applied Silicone Sealants. When checking for adhesions of silicone, a pull test may be performed on the job site 21 days after the sealant has been placed.

(1) Make a knife cut horizontally across and through the silicone from one side of the joint to the other.

(2) Make a vertical cut approximately 2-3 inches long on each side of the joint starting at the horizontal cut, keeping the cuts the same length on each side.

(3) Hold the piece of silicone firmly and slowly pull at a 90° angle stretching the silicone not more than 10” per minute as if trying to pull the adhered silicone out of the joint.

(4) If adhesion is proper, the silicone will not pull out of the joint, but will eventually tear cohesively across the joint at the base of the knife cut.

b. If the silicone releases from the joint, adhesion has been affected. Several possible causes are:

(1) Moisture in the joint during sealant application

(2) Dirty of dusty joint sidewalls
(3) Improper application (overfilling, etc.)

(4) Spalling of the joint walls. (pieces of the concrete will be adhered to the silicone)

c. **Repair Of Sealant In Areas Of Adhesion Test.** The silicone sealant may be replaced by simply applying additional new silicone (normally using a tube of like silicone) in the same manner as it was originally placed, providing good adhesion was achieved. Proper preparation of the area should be performed prior to reapplying the silicone assuring the original silicone and the newly applied silicone are in good contact with each other.

**605-3.8 WARRANTY.** The manufacturer shall provide a warranty on the materials furnished for a minimum of 5 years from the date of acceptance by the Project Manager. The Contractor shall provide a warranty on the installation for a minimum of 2 years from the date of acceptance by the Project Manager.

**METHOD OF MEASUREMENT**

**605-4.1** There shall be no direct measurement or payment for joint sealing filler. The work under this item shall be considered subsidiary to other items of work.

**BASIS OF PAYMENT**

**605-5.1** Joint sealing filler shall be considered incidental to the project. No payment shall be made for joint sealing filler.

**TESTING REQUIREMENTS**

- ASTM D1644 Standard Test Methods for Nonvolatile Content of Varnishes

**MATERIAL REQUIREMENTS**

- AC 150/5340-30 Design and Installation Details for Airport Visual Aids
- ASTM D6690 Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
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 bituminous concrete pavements must be formulated so they are compatible with the bituminous concrete.

EQUIPMENT AND 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).

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.

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 ASTM D1168, 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.

Table 1. Property Requirements

<table>
<thead>
<tr>
<th>Physical or Electrical Property</th>
<th>Minimum</th>
<th>Maximum</th>
<th>ASTM Method</th>
</tr>
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<tbody>
<tr>
<td>Tensile</td>
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<tr>
<td>Portland cement concrete</td>
<td>1,000 psi (70 kg/sq cm)</td>
<td>D 638</td>
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</tr>
<tr>
<td>Bituminous concrete</td>
<td>500 psi (35 kg/sq cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elongation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portland cement concrete</td>
<td></td>
<td>See note 1</td>
<td>D 638</td>
</tr>
<tr>
<td>Bituminous concrete</td>
<td></td>
<td>50%</td>
<td>D 638</td>
</tr>
<tr>
<td>Coef. of cub. exp. cu. cm/cu. cm/°C</td>
<td>0.00090</td>
<td>0.00120</td>
<td>D 1168</td>
</tr>
<tr>
<td>Coef. of lin. exp. cm/cm/°C</td>
<td>0.000030</td>
<td>0.000040</td>
<td>D 1168</td>
</tr>
<tr>
<td>Dielectric strength, short time test</td>
<td>350 volts/mil.</td>
<td></td>
<td>D 149</td>
</tr>
<tr>
<td>Arc resistance</td>
<td>125 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pull-off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adhesion to steel</td>
<td>1,000 psi (70 kg/sq cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adhesion to Portland cement concrete</td>
<td>200 psi (14 kg/sq cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adhesion to asphalt concrete</td>
<td>No test available.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adhesion to aluminum</td>
<td>250 psi</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 20% or more (without filler) for formulations to be supplied for areas subject to freezing.

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, ±0.5, bags of cement per cubic yard (0.76
cubic meter) of concrete, and a slump of 2-1/2 inch (60 mm), ±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%, ±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
cement saw having a diamond blade. The concrete shall be prepared and cured in
accordance with ASTM C192.

<table>
<thead>
<tr>
<th>Table 2. Aggregate For Bond Test Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>Coarse Aggregate</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Fine Aggregate</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
</tbody>
</table>
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 ±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 CONCRETE.** 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 [Portland cement concrete] [bituminous concrete] pavements. The report shall be delivered to the DEN Project Manager before permission is granted for 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.

A manufacturer’s representative shall be present for the initial installation of the sealing material. The representative shall remain on site until the DEN Project Manager is satisfied the installation crew is performing in accordance with the specifications and the manufacturer’s guide lines.

**METHOD OF MEASUREMENT**

**606-4.1** There shall be no direct measurement or payment for adhesive. The work under this item shall be considered subsidiary to other items of work.

**BASIS OF PAYMENT**

**606-5.1** Adhesive shall be considered incidental to the project. No payment shall be made for adhesive.

**TESTING REQUIREMENTS**

ASTM C192  Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ITEM P-606 ADHESIVE COMPOUNDS, TWO-COMPONENT FOR SEALING WIRE AND LIGHTS IN PAVEMENT

END OF ITEM P-606
ITEM P-610 STRUCTURAL PORTLAND CEMENT CONCRETE

DESCRIPTION

610-1.1 This item shall consist of [plain] [reinforced] structural portland cement concrete (PCC), prepared and constructed in accordance with these specifications, at the locations and of the form and dimensions shown on the plans. This specification shall be used for all structural and miscellaneous concrete including signage bases.

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 DEN Project 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 and Coarse aggregates to be used in all concrete shall be evaluated and tested by the Contractor for alkali-aggregate reactivity in accordance with both ASTM C1260 and C1567. The laboratory performing the tests shall be accredited in accordance with ASTM C1077. The laboratory accreditation must be current and listed on the accrediting authority’s website. Test method ASTM C1260 must be listed on the lab accreditation. A copy of the laboratory’s current accreditation and accredited test methods shall be submitted to the DEN Project Manager prior to start of construction. Aggregate and mix proportion reactivity tests shall be performed for each project.

(1) Coarse and fine aggregate shall be tested separately in accordance with ASTM C1260. The aggregate shall be considered innocuous if the expansion of test specimens, tested in accordance with ASTM C1260, does not exceed 0.10% at 28 days (30 days from casting).

(2) 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
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) CRD C662. If lithium nitrate admixture is used, it shall be nominal 30% ±0.5% weight lithium nitrate in water.

(3) If the expansion of the proposed combined materials test specimens, tested in accordance with ASTM C1567, modified for combined aggregates, or COE CRD C662, does not exceed 0.10% at 28 days, the proposed combined materials will be accepted. If the expansion of the proposed combined materials test specimens 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.

610-2.2 COARSE AGGREGATE. The coarse aggregate for concrete shall meet the requirements of ASTM C33. Crushed stone aggregate shall have a durability factor, as determined by ASTM C666, greater than or equal to 95. The DEN Project Manager may consider and reserve final approval of other State classification procedures addressing aggregate durability.

Coarse aggregate shall be well graded from coarse to fine and shall meet the following gradation shown in the table below when tested per ASTM C136.

### Gradation For Coarse Aggregate

<table>
<thead>
<tr>
<th>Sieve Designation (square openings)</th>
<th>Percentage by Weight Passing Sieves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2&quot; (50 mm)</td>
</tr>
<tr>
<td>No. 4 to ¾ in. (4.78-19mm)</td>
<td>100</td>
</tr>
<tr>
<td>No. 4 to 1 in. (4.75-25mm)</td>
<td>100</td>
</tr>
<tr>
<td>No. 4 to 1-1/2 in. (4.75-38mm)</td>
<td>100</td>
</tr>
</tbody>
</table>

a. Aggregate Susceptibility to Durability (D) Cracking. [Aggregates that have a history of D-cracking shall not be used.]

b. [Coarse aggregate may be accepted from sources that have a 20 year service history for the same gradation to be supplied with no durability issues.

(1) Material currently being produced shall have a durability factor ≥ 95 using ASTM C666. Coarse aggregates that are crushed granite, calcite cemented sandstone, quartzite, basalt, diabase, rhyolite or trap rock are considered to meet the D-
cracking test but must meet all other quality tests. Aggregates meeting State Highway Department material specifications may be acceptable with concurrence of the FAA.

(2) The Contractor shall submit a current certification that the aggregate does not have a history of D-cracking and that the aggregate meets the state specifications for use in PCC pavement for use on interstate highways. Certifications, tests and any history reports must be for the same gradation as being proposed for use on the project. Certifications which are not dated or which are over one (1) year old or which are for different gradations will not be accepted. Test results will only be accepted when tests were performed by a State Department of Transportation (DOT) materials laboratory or an accredited laboratory.

610-2.3 Fine Aggregate. The fine aggregate for concrete shall meet the requirements of ASTM C33.

The fine aggregate shall be well graded from fine to coarse and shall meet the requirements of the table below when tested in accordance with ASTM C136:

<table>
<thead>
<tr>
<th>Sieve Designation (square openings)</th>
<th>Percentage by Weight Passing Sieves</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch (9 mm)</td>
<td>100</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>95-100</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
<td>45-80</td>
</tr>
<tr>
<td>No. 30 (0.60 mm)</td>
<td>25-55</td>
</tr>
<tr>
<td>No. 50 (0.30 mm)</td>
<td>10-30</td>
</tr>
<tr>
<td>No. 100 (0.15 mm)</td>
<td>2-10</td>
</tr>
</tbody>
</table>

Blending will be permitted, if necessary, to meet the gradation requirements for fine aggregate. Fine aggregate deficient in the percentage of material passing the No. 50 mesh sieve may be accepted, if the deficiency does not exceed 5% and is remedied by the addition of pozzolanic or cementitious materials other than Portland cement, as specified in paragraph 610-2.6. Admixtures, in sufficient quantity to produce the required workability as approved by the DEN Project Manager.

610-2.4 CEMENT. Cement shall conform to the requirements of [ASTM C150] Type [V].

If aggregates are deemed innocuous when tested in accordance with paragraph 610-2.1.a.1 and accepted in accordance with paragraph 610-2.1.a.3, higher equivalent alkali content in the cement may be allowed if approved by the DEN Project Manager and FAA. 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.
The Contractor shall furnish vendors’ certified test reports for each carload, or equivalent, of cement shipped to the project. The report shall be delivered to the DEN Project Manager before use of the cement is granted. All test reports shall be subject to verification by testing sample materials received for use on the project.

610-2.5 WATER. The water used in concrete shall be fresh, clean and potable; free from injurious amounts of oils, acids, alkalies, salts, organic materials or other substances deleterious to concrete.

610-2.6 ADMIXTURES. The Contractor shall submit certificates indicating that the material to be furnished meets all of the requirements indicated below. In addition, the DEN Project Manager 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 DEN Project 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 DEN Project Manager. 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:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Limit (Percent by Mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LiNO3 (Lithium Nitrate)</td>
<td>30 ±0.5</td>
</tr>
<tr>
<td>SO4 (Sulfate Ion)</td>
<td>0.1 (max)</td>
</tr>
<tr>
<td>Cl (Chloride Ion)</td>
<td>0.2 (max)</td>
</tr>
<tr>
<td>Na (Sodium Ion)</td>
<td>0.1 (max)</td>
</tr>
<tr>
<td>K (Potassium Ion)</td>
<td>0.1 (max)</td>
</tr>
</tbody>
</table>

Provide a trained representative to supervise the lithium nitrate admixture dispensing and mixing operations.

e. 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 for use
in mitigating alkali-silica reactivity shall have a Calcium Oxide (CaO) content of less than 13%.]

610-2.7 PREMOLDED JOINT MATERIAL. Premolded joint material for expansion joints shall meet the requirements of ASTM [D1751].

610-2.8 JOINT FILLER. The filler for joints shall meet the requirements of Item P-605, unless otherwise specified.

610-2.9 STEEL REINFORCEMENT. Reinforcing shall consist of [bar mats] conforming to the requirements of [ASTM A184].

610-2.10 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 DEN Project Manager.

610-3.2 CONCRETE COMPOSITION. The concrete shall develop a compressive strength of [___] psi 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 (cement plus fly ash) per cubic yard (280 kg per cubic meter). The concrete shall contain 5% of entrained air, ±1%, 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 ACCEPTANCE SAMPLING AND TESTING. Concrete for each structure will be accepted on the basis of the compressive strength specified in paragraph 610-3.2. The concrete shall be sampled in accordance with ASTM C172. The first load of concrete, per mix, delivered each day will be sampled and tested.

Concrete placed for structures will be sampled and tested for each additional 50 cubic yards per day with a minimum one test per structure. When a single load of concrete is used for more than one structure, that load will be sampled and tested once.

Concrete placed for light cans will be sampled and tested for each additional 50 cubic yards per day.

Lean concrete will be sampled and tested for each additional 50 cubic yards per day.

Concrete cylindrical compressive strength specimens shall be made in accordance with ASTM C31 and tested in accordance with ASTM C39. Concrete strengths for acceptance
shall be the average of at least two 6 by 12 inch or at least three 4 by 8 inch cylinders tested at 28 days. Contractor shall provide the initial on-site storage facilities for the specimens. The on-site storage facilities shall be capable of maintaining a temperature range of 60 to 80°F (16 to 27°C). The Contractor shall cure and store the test specimens under such conditions as directed by the Engineer. The DEN Project Manager/Engineer will make the actual tests on the specimens at no expense to the Contractor.

610-3.4 QUALIFICATIONS FOR CONCRETE TESTING SERVICE. Perform concrete testing by an approved laboratory and inspection service experienced in sampling and testing concrete. Testing agency must meet the requirements of ASTM C1077 or ASTM E329.

610-3.5 PROPORTIONING AND MEASURING DEVICES. When package cement is used, the quantity for each batch shall be equal to one or more whole sacks of cement. The aggregates shall be measured separately by weight. If aggregates are delivered to the mixer in batch trucks, the exact amount for each mixer charge shall be contained in each batch compartment. Weighing boxes or hoppers shall be approved by the DEN Project Manager and shall provide means of regulating the flow of aggregates into the batch box so the required, exact weight of aggregates is obtained.

610-3.6 CONSISTENCY. The consistency of the concrete shall be determined by the slump test specified in ASTM C143.

610-3.7 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.

610-3.8 MIXING CONDITIONS. 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 permission of the DEN Project Manager. If permission 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 shall not be permitted.

The rate of delivery of concrete to the job shall be sufficient to allow uninterrupted placement of the concrete.

610-3.9 FORMS. Concrete shall not be placed until all the forms and reinforcements have been inspected and approved by the DEN Project 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. The forms shall not be removed until at least 30 hours after concrete placement for vertical faces, walls, slender columns, and similar structures. Forms supported by falsework under slabs, beams, girders, arches, and similar construction shall not be removed until tests indicate the concrete has developed at least 60% of the design strength.

610-3.10 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.

610-3.11 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.

610-3.12 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 DEN Project 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.

610-3.13 VIBRATION. Vibration shall follow the guidelines in American Concrete Institute (ACI) Committee 309, Guide for Consolidation of Concrete. Where bars meeting ASTM A775 or A934 are used, the vibrators shall be equipped with rubber or non-metallic vibrator heads. Furnish a spare, working, vibrator on the job site whenever concrete is placed. Consolidate concrete slabs greater than 4 inches (100 mm) in depth with high frequency mechanical vibrating equipment supplemented by hand spading and tamping. Consolidate concrete slabs 4 inches (100 mm) or less in depth by wood tampers, spading, and settling with a heavy leveling straightedge. Operate internal vibrators with vibratory element submerged in the concrete, with a minimum frequency of not less than 6000 cycles per minute when submerged. Do not use vibrators to transport the concrete in the forms. Penetrate the previously placed lift with the vibrator when more than one lift is required. Use
external vibrators on the exterior surface of the forms when internal vibrators do not provide adequate consolidation of the concrete. Vibrators shall be manipulated to work the concrete thoroughly around the reinforcement and embedded fixtures and into corners and angles of the forms. The vibration at any point shall be of sufficient duration to accomplish compaction but shall not be prolonged to where segregation occurs. Concrete deposited under water shall be carefully placed in a compact mass in its final position by means of a tremie or other approved method and shall not be disturbed after placement.

610-3.14 CONSTRUCTION JOINTS. If the placement of concrete is suspended, necessary provisions shall be made for joining future work before the placed concrete takes its initial set. For the proper bonding of old and new concrete, provisions shall be made for grooves, steps, reinforcing bars or other devices as specified. The work shall be arranged so that a section begun on any day shall be finished during daylight of the same day. Before depositing new concrete on or against concrete that has hardened, the surface of the hardened concrete shall be cleaned by a heavy steel broom, roughened slightly, wetted, and covered with a neat coating of cement paste or grout.

610-3.15 EXPANSION JOINTS. Expansion joints shall be constructed at such points and dimensions as indicated on the drawings. The premolded filler shall be cut to the same shape as the surfaces being joined. The filler shall be fixed firmly against the surface of the concrete already in place so that it will not be displaced when concrete is deposited against it.

610-3.16 DEFECTIVE WORK. Any defective work discovered after the forms have been removed, which in the opinion of the DEN Project Manager cannot be repaired satisfactorily, shall be immediately removed and replaced at the expense of the Contractor. Defective work shall include deficient dimensions, or bulged, uneven, or honeycomb on the surface of the concrete.

610-3.17 SURFACE FINISH. 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. Mortar finishing shall not be permitted, nor shall dry cement or sand-cement mortar be spread over the concrete during the finishing of horizontal plane surfaces.

The surface finish of exposed concrete shall be a rubbed finish. If forms can be removed while the concrete is still green, the surface shall be wetted and then rubbed with a wooden float until all irregularities are removed. If the concrete has hardened before being rubbed, a carborundum stone shall be used to finish the surface. When approved, the finishing can be done with a finishing machine.

610-3.18 CURING AND PROTECTION. All concrete shall be properly cured and protected by the Contractor. The concrete shall be protected from the weather, flowing water, and from defacement of any nature during the project. The concrete shall be cured by covering with an approved material as soon as it has sufficiently hardened. Water-absorptive coverings shall be thoroughly saturated when placed and kept saturated for at least three (3) days following concrete placement. All curing mats or blankets shall be sufficiently weighted.
or tied down to keep the concrete surface covered and to prevent the surface from being exposed to air currents. Wooden forms shall be kept wet at all times until removed to prevent opening of joints and drying out of the concrete. Traffic shall not be allowed on concrete surfaces for seven (7) days after the concrete has been placed.

610-3.19 **DRAINS OR DUCTS.** Drainage pipes, conduits, and ducts that are to be encased in concrete shall be installed by the Contractor before the concrete is placed. The pipe shall be held rigidly so that it will not be displaced or moved during the placing of the concrete.

610-3.20 **COLD WEATHER PROTECTION.** When concrete is placed at temperatures below 40°F (4°C), the Contractor shall provide satisfactory methods and means to protect the mix from injury by freezing. The aggregates, or water, or both, shall be heated to place the concrete at temperatures between 50°F and 100°F (10°C and 38°C).

Calcium chloride may be incorporated in the mixing water when directed by the DEN Project Manager. Not more than 2 pounds (908 grams) of Type 1 or more than 1.6 pounds (726 grams) of Type 2 shall be added per bag of cement. After the concrete has been placed, the Contractor shall provide sufficient protection such as cover, canvas, framework, heating apparatus, etc., to enclose and protect the structure and maintain the temperature of the mix at not less than 50°F (10°C) until at least 60% of the designed strength has been attained.

610-3.21 **HOT WEATHER PLACING.** Concrete shall be properly placed and finished with procedures previously submitted. The concrete-placing temperature shall not exceed [85°F (29°C)] when measured in accordance with ASTM C1064. Cooling of the mixing water and aggregates, or both, may be required to obtain an adequate placing temperature. A retarder meeting the requirements of paragraph 610-2.6 may be used to facilitate placing and finishing. Steel forms and reinforcement shall be cooled prior to concrete placement when steel temperatures are greater than 120°F (50°C). Conveying and placing equipment shall be cooled if necessary to maintain proper concrete-placing temperature. Submit the proposed materials and methods for review and approval by the DEN Project Manager, if concrete is to be placed under hot weather conditions.

610-3.22 **FILLING JOINTS.** All joints that require filling shall be thoroughly cleaned, and any excess mortar or concrete shall be cut out with proper tools. Joint filling shall not start until after final curing and shall be done only when the concrete is completely dry. The cleaning and filling shall be done with proper equipment to obtain a neat looking joint free from excess filler.

**METHOD OF MEASUREMENT**

**610-4.1** In general, and unless listed in the proposal as a separate payment item, structural concrete will not be measured for payment, but shall be incidental to those proposed items constructed of concrete.

**610-4.2** Cement Treated Base (CTB) repair shall be measured per square yard including existing cement treated base milling and structural concrete installation.
BASIS OF PAYMENT

610-5.1 Structural concrete shall be considered incidental to the project. No payment shall be made for structural concrete, unless listed in the proposal as a separate payment item.

Payment for Cement Treated Base Repair shall be made at the contract unit price per square yard. This price shall be full compensation for furnishing all labor, material, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-610-5.1 Cement Treated Base Repair – per square yard (square meter)

TESTING REQUIREMENTS

ASTM C31 Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
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 C143 Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C231 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C666 Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
ASTM C1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1064 Standard 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
<table>
<thead>
<tr>
<th>ASTM Standard</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>E329</td>
<td>Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection</td>
</tr>
<tr>
<td>C662</td>
<td>Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)</td>
</tr>
</tbody>
</table>

**MATERIAL REQUIREMENTS**

<table>
<thead>
<tr>
<th>ASTM Standard</th>
<th>Description</th>
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<tbody>
<tr>
<td>A184</td>
<td>Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement</td>
</tr>
<tr>
<td>A185</td>
<td>Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete</td>
</tr>
<tr>
<td>A615</td>
<td>Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement</td>
</tr>
<tr>
<td>A704</td>
<td>Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement</td>
</tr>
<tr>
<td>A706</td>
<td>Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement</td>
</tr>
<tr>
<td>A775</td>
<td>Standard Specification for Epoxy-Coated Steel Reinforcing Bars</td>
</tr>
<tr>
<td>A934</td>
<td>Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars</td>
</tr>
<tr>
<td>A1064</td>
<td>Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete</td>
</tr>
<tr>
<td>C33</td>
<td>Standard Specification for Concrete Aggregates</td>
</tr>
<tr>
<td>C94</td>
<td>Standard Specification for Ready-Mixed Concrete</td>
</tr>
<tr>
<td>C150</td>
<td>Standard Specification for Portland Cement</td>
</tr>
<tr>
<td>C171</td>
<td>Standard Specification for Sheet Materials for Curing Concrete</td>
</tr>
<tr>
<td>C172</td>
<td>Standard Practice for Sampling Freshly Mixed Concrete</td>
</tr>
<tr>
<td>C260</td>
<td>Standard Specification for Air-Entraining Admixtures for Concrete</td>
</tr>
<tr>
<td>C309</td>
<td>Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete</td>
</tr>
<tr>
<td>C494</td>
<td>Standard Specification for Chemical Admixtures for Concrete</td>
</tr>
<tr>
<td>C595</td>
<td>Standard Specification for Blended Hydraulic Cements</td>
</tr>
<tr>
<td>C618</td>
<td>Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete</td>
</tr>
</tbody>
</table>
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

ACI 305R Hot Weather Concreting

ACI 306R Cold Weather Concreting

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 DEN Project 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. The reports can be used for material acceptance or the DEN Project Manager may perform verification testing. The reports shall not be interpreted as a basis for payment. The Contractor shall notify the DEN Project Manager upon arrival of a shipment of materials to the site. All material shall arrive in sealed containers 55 gallons or smaller for inspection by the DEN Project Manager. Material shall not be loaded into the equipment until inspected by the DEN Project Manager.

620-2.2 MARKING MATERIALS. Paint shall be [waterborne, epoxy, methacrylate, solvent-base, or preformed thermoplastic] in accordance with the requirements of paragraph 620-2.2 [___]. Paint shall be furnished in [___] in accordance with Federal Standard No. 595.

a. Waterborne. Paint shall meet the requirements of Federal Specification TT-P-1952E, [Type I, Type II] [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⁻¹ with intensities equal to those produced by an acrylic resin known to be 100% cross linking.]

b. [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.
TECHNICAL SPECIFICATIONS

DIVISION 2 – AIRFIELD STANDARDS

DENVER INTERNATIONAL AIRPORT

ITEM P-620 RUNWAY AND TAXIWAY MARKING

2017 ANNUAL AIRFIELD PAVEMENT REHABILITATION

CONTRACT NO. 201733182

(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] [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 kg) (±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.

<table>
<thead>
<tr>
<th>Size Gradation</th>
<th>Retained, %</th>
<th>Passing, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Mesh μm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 1700</td>
<td>0 - 2</td>
<td>98 - 100</td>
</tr>
<tr>
<td>14 1400</td>
<td>0 - 3.5</td>
<td>96.5 - 100</td>
</tr>
<tr>
<td>16 1180</td>
<td>2 - 25</td>
<td>75 - 98</td>
</tr>
<tr>
<td>18 1000</td>
<td>28 - 63</td>
<td>37 - 72</td>
</tr>
<tr>
<td>20 850</td>
<td>63 - 72</td>
<td>28 - 37</td>
</tr>
<tr>
<td>30 600</td>
<td>67 - 77</td>
<td>23 - 33</td>
</tr>
<tr>
<td>50 300</td>
<td>89 - 95</td>
<td>5 - 11</td>
</tr>
<tr>
<td>80 200</td>
<td>97 - 100</td>
<td>0 - 3</td>
</tr>
</tbody>
</table>

(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:

<table>
<thead>
<tr>
<th>x</th>
<th>.462</th>
<th>x</th>
<th>.470</th>
<th>x</th>
<th>.479</th>
<th>x</th>
<th>.501</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>.438</td>
<td>y</td>
<td>.455</td>
<td>y</td>
<td>.428</td>
<td>y</td>
<td>.452</td>
</tr>
</tbody>
</table>

(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.

(12) 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, anti-icers, 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 re-opened to traffic after application.

(e) The marking material shall have an integral color throughout the thickness of the marking material.

620-2.3 REFLECTIVE MEDIA FOR WATERBORNE MARKINGS. Glass beads 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.

CONSTRUCTION METHODS

620-3.1 WEATHER LIMITATIONS. The painting shall be performed only when the surface is dry and when the surface temperature is at least 45°F (7°C) and rising and the pavement surface temperature is at least 5°F (2.7°C) above the dew point or meets the manufacturer’s recommendations. [Painting operations shall be discontinued when the surface temperature exceeds [____]°F (____°C).] [Markings shall not be applied when the pavement temperature is greater than 130°F (55°C).] Markings shall not be applied
when the wind speed exceeds 10 mph unless windscreens are used to shroud the material guns.

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 suitable for application of traffic paint. It shall produce an even and uniform film thickness at the required coverage and shall apply markings of uniform cross-sections and clear-cut edges without running or spattering and without over spray.

620-3.3 PREPARATION OF SURFACE. Immediately before application of the paint, the surface shall be dry and free from dirt, grease, oil, laitance, or other foreign material that would reduce the bond between the paint and the pavement. The area to be painted shall be cleaned by sweeping and blowing or by other methods as required to remove all contaminants minimizing damage to the pavement surface. Use of any chemicals or impact abrasives during surface preparation shall be approved in advance by the DEN Project Manager. 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.

[Paint shall not be applied to Portland cement concrete pavement until the areas to be painted are clean of curing material. Sandblasting or high-pressure water shall be used to remove curing materials.]

[At least 24 hours prior to remarking existing markings, [loose] existing markings must be removed such that [75%] [90%] [100%] of the [loose] existing markings are removed. After removal, the surface shall be cleaned of all residue or debris either with sweeping or blowing with compressed air or both.]

Prior to the application of any markings, the Contractor shall certify in writing that the surface has been prepared in accordance with the paint manufacturer’s requirements, that the application equipment is appropriate for the type of marking paint and that environmental conditions are appropriate for the material being applied. This certification along with a copy of the paint manufacturer’s surface preparation and application requirements must be submitted and approved by the DEN Project 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. [The locations of markings to receive silica sand shall be shown on the plans.]

620-3.5 APPLICATION. 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 DEN Project 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 spacings shall be within the following tolerances:

<table>
<thead>
<tr>
<th>Dimension and Spacing</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>36 inch (910 mm) or less</td>
<td>±1/2 inch (12 mm)</td>
</tr>
<tr>
<td>greater than 36 inch to 6 feet (910 mm to 1.85 m)</td>
<td>±1 inch (25 mm)</td>
</tr>
<tr>
<td>greater than 6 feet to 60 feet (1.85 m to 18.3 m)</td>
<td>±2 inch (50 mm)</td>
</tr>
<tr>
<td>greater than 60 feet (18.3 m)</td>
<td>±3 inch (76 mm)</td>
</tr>
</tbody>
</table>

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.

[A period of 30 days shall elapse between placement of a bituminous surface course or seal coat and application of the paint. If pavement is required to be opened to traffic prior to the 30 days, temporary markings shall be applied with an application rate of 50% with no glass beads are required. White paint shall have temporary and permanent applications regardless of the time period between placement of the bituminous surface course or seal coat and application of paint.]

[A period of 8 weeks shall elapse between placement of a concrete pavement and application of the paint. If pavement is required to be opened to traffic prior to the 8 weeks, temporary markings shall be applied at an application rate of 50% and no glass beads are required.]

Prior to the initial application of markings, the Contractor shall certify in writing that the surface has been prepared in accordance with the paint manufacturer’s requirements, that the application equipment is appropriate for the marking paint and that environmental conditions are appropriate for the material being applied. This certification along with a copy of the paint manufactures application and surface preparation requirements must be submitted to the DEN Project Manager prior to the initial application of markings.

620-3.6 TEST STRIP. Prior to the full application of airfield markings, the Contractor shall produce a test strip in the presence of the DEN Project Manager. The test strip shall include the application of a minimum of 5 gallons (4 liters) of paint and application of 35 lbs (15.9 kg) of Type I/50 lbs (22.7 kg) of Type III glass beads. The test strip shall be used to establish thickness/darkness standard for all markings. The test strip shall cover no more than the maximum area prescribed in Table 1 (e.g., for 5 gallons (19 liters) of waterborne paint shall cover no more than 575 square feet (53.4 m²).
Table 1. Application Rates For Paint And Glass Beads
(See Note regarding Red and Pink Paint)

<table>
<thead>
<tr>
<th>Paint Type</th>
<th>Paint Square feet per gallon, ft²/gal (Sq m per liter, m²/l)</th>
<th>Glass Beads, Type I, Gradation A Pounds per gallon of paint-lb/gal (Kg per liter of paint-kg/l)</th>
<th>Glass Beads, Type III Pounds per gallon of paint-lb/gal (Kg per liter of paint-kg/l)</th>
<th>Glass Beads, Type IV Pounds per gallon of paint-lb/gal (Kg per liter of paint-kg/l)</th>
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</tbody>
</table>

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 should be performed.

All emptied containers shall be returned to the paint storage area for checking by the DEN Project Manager. The containers shall not be removed from the airport or destroyed until authorized by the DEN Project Manager.

620-3.7 APPLICATION--PREFORMED TERMOPLASTIC AIRPORT PAVEMENT MARKINGS.

a. Asphalt and Portland cement. To ensure minimum single-pass application time and optimum bond in the marking/substrate interface, the materials must be applied using a variable speed self-propelled mobile heater with an effective heating width of no less than 16 feet (5 m) and a free span between supporting wheels of no less than 18 feet (5.5 m). The heater must emit thermal radiation to the marking material in such a manner that the difference in temperature of 2 inches (50 mm) wide linear segments in the direction of heater travel must be within 5% of the overall average temperature of the heated thermoplastic material as it exits the heater. The material must be able to be applied at ambient and pavement temperatures down to 35°F (2°C) without any preheating of the pavement to a specific temperature. The material must be able to be applied without the use of a thermometer. 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. The Contractor shall protect the pavement from damage during application of thermoplastic markings.
620-3.8 **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 or unadhered reflective media, and by-products generated by the surface preparation and application operations to the satisfaction of the DEN Project Manager. The Contractor shall dispose of these wastes in strict compliance with all applicable state, local, and Federal environmental statutes and regulations.

**METHOD OF MEASUREMENT**

620-4.1 The quantity of 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 DEN Project Manager.

**BASIS OF PAYMENT**

620-5.1 Payment shall be made at the respective contract price per square foot (square meter) for markings. This price shall be full compensation for furnishing all materials and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

- Item P-620-5.1 Pavement Marking – per square foot (square meter)
- P-620-5.2 Non-Reflective Pavement Marking – per square foot
- P-620-5.3 Thermoplastic Pavement Marking – per square foot
- P-620-5.4 Temporary Pavement Marking – per square foot

**TESTING REQUIREMENTS**

- ASTM C371 Standard Test Method for Wire-Cloth Sieve Analysis of Nonplastic Ceramic Powders
- ASTM D92 Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
- 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
TECHNICAL SPECIFICATIONS  
DIVISION 2 – AIRFIELD STANDARDS  
DENVER INTERNATIONAL AIRPORT  
2017 ANNUAL AIRFIELD PAVEMENT REHABILITATION  
ITEM P-620 RUNWAY AND TAXIWAY MARKING  
CONTRACT NO. 201733182


ASTM G154  Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

MATERIAL REQUIREMENTS

ASTM D476  Standard Classification for Dry Pigmentary Titanium Dioxide Products

40 CFR Part 60, Appendix A-7, Method 24  Determination of volatile matter content, water content, density, volume solids, and weight solids of surface coatings


FED SPEC TT-B-1325D  Beads (Glass Spheres) Retro-Reflective

American Association of State Highway and Transportation Officials (AASHTO) M247  Standard Specification for Glass Beads Used in Pavement Markings

FED SPEC TT-P-1952E  Paint, Traffic and Airfield Marking, Waterborne

Commercial Item Description A-A-2886B  Paint, Traffic, Solvent Based

FED STD 595  Colors used in Government Procurement

AC 150/5340-1  Standards for Airport Markings

END OF ITEM P-620
ITEM P-621 SAW-CUT GROOVES

DESCRIPTION

621-1.1 This item consists of providing a skid resistant surface that prevents hydroplaning during wet weather in accordance with these specifications and at the locations shown on the plans, or as directed by the DEN Project Manager.

CONSTRUCTION METHODS

621-2.1 PROCEDURES. The Contractor shall submit to the DEN Project 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 (+1/16 inch, -0 inch) wide by 1/4 inch (±1/16 inch) deep by 1-1/2 inch (-1/8 inch, +0 inch) [6 mm (+2 mm, -0 mm) wide by 6 mm (±2 mm) deep by 38 mm (-3 mm, +0 mm)] center-to-center configuration. Alternatively, transverse trapezoidal-shaped grooves are allowed. Transverse trapezoidal-shaped grooves saw-cut in the pavement must form a 1/2 inch (13 mm) wide opening at the top and 1/4 inch (6 mm) wide bottom surface by 1/4 inch (6 mm) deep by 2-1/4 inch (57 mm) 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 ±1-1/2 inch (38 mm) in alignment for 75 feet (23 m) along the runway [or taxiway] length, allowing for realignment every 500 feet (150 m) along the runway [or taxiway] 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).

c. **Groove Tolerance – Trapezoidal Grooves.**

(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 1/2 inch (12 mm) opening at the top and a 1/4 inch (6 mm) wide bottom surface. At least 90% of the grooves must be within 1/16 inch (2 mm) minus of these dimensions, at least 60% of the grooves must be at these dimensions, and not more than 10% of the grooves may exceed 1/16 inch (2 mm) plus of these dimensions.

(3) **Center-to-center spacing.** The standard spacing is 2-1/4 inches (57 mm). Minimum spacing 2-1/8 inches (54 mm). Maximum spacing 2-1/4 inches (57 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 **TEST SECTION.** Groove a test section in an area of the pavement outside of the trafficked area, as approved by the DEN Project Manager. The area shall be [ ] feet ( [ ] m) 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 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. Permit new Portland cement
concrete pavements to cure for a minimum of 28 days before grooving. Spalling along or tearing or raveling of the groove edges shall not be allowed. New pavement shall not be grooved until smoothness and grade corrections are completed in the area to be grooved.

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 DEN Project 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, in the opinion of the DEN Project Manager, the result of the grooving operation will be detrimental to aircraft tires.

621.2.10 [PRODUCTION RATE. The Contractor must furnish sufficient equipment to groove [__ square yards] of pavement [per hour] [per day].]

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 DEN Project 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 DEN Project 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 runway or taxiway centerline.

Zone 2  5 feet (1.5 m) to 25 feet (7.5 m) left of the runway centerline.

Zone 3  5 feet (1.5 m) to 12.5 feet (3 m) left of the taxiway centerline.

Zone 4  25 feet (7.5 m) to edge of grooving left of the runway centerline.

Zone 5  25 feet (7.5 m) to edge of grooving right of the runway 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.

621-3.2  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 DEN Project Manager per paragraph 621-3.1.

**BASIS OF PAYMENT**
621-5.1 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)

END OF ITEM P-621
ITEM T-901 SEEDING

****************************************************

DESCRIPTION

901-1.1 This item shall consist of soil preparation, seeding, and fertilizing the areas shown on the plans or as directed by the DEN Project Manager in accordance with these specifications.

MATERIALS

901-2.1 SEED The species and application rates of grass, legume, and cover-crop seed furnished shall be those stipulated herein. Seed shall conform to the requirements of Federal Specification JJJ-S-181, Federal Specification, Seeds, Agricultural.

Seed shall be furnished separately or in mixtures in standard containers labeled in conformance with the Agricultural Marketing Service (AMS) Seed Act and applicable state seed laws with the seed name, lot number, net weight, percentages of purity and of germination and hard seed, and percentage of maximum weed seed content clearly marked for each kind of seed. The Contractor shall furnish the DEN Project Manager duplicate signed copies of a statement by the vendor certifying that each lot of seed has been tested by a recognized laboratory for seed testing within six (6) months of date of delivery. This statement shall include: name and address of laboratory, date of test, lot number for each kind of seed, and the results of tests as to name, percentages of purity and of germination, and percentage of weed content for each kind of seed furnished, and, in case of a mixture, the proportions of each kind of seed. Wet, moldy, or otherwise damaged seed will be rejected.

Seeds shall be applied as follows:

Mix Design 1 - Non-saline Upland Seed Mix, Denver International Airport

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Variety</th>
<th>lbs PLS /acre*</th>
<th>% of mix**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GRASSES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bouteloua curtipendula</td>
<td>Sideoats Grama</td>
<td>Vaughn</td>
<td>0.8</td>
<td>10</td>
</tr>
<tr>
<td>Bouteloua gracilis</td>
<td>Blue Grama</td>
<td>Bad River</td>
<td>0.05</td>
<td>2.5</td>
</tr>
<tr>
<td>Bouteloua gracilis</td>
<td>Blue Grama</td>
<td>Hachita</td>
<td>0.05</td>
<td>2.5</td>
</tr>
<tr>
<td>Buchloe dactyloides</td>
<td>Buffalograss</td>
<td>Cody</td>
<td>0.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Item</td>
<td>Seed Type</td>
<td>Variety</td>
<td>Coverage</td>
<td>Density</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------</td>
<td>------------------------</td>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td>Buchloe dactyloides</td>
<td>Buffalograss</td>
<td>Native - VNS†</td>
<td>0.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Distichlis spicata v.</td>
<td>Inland Saltgrass</td>
<td>Native - VNS†</td>
<td>0.3</td>
<td>5</td>
</tr>
<tr>
<td>Elymus lanceolatus</td>
<td>Thickspike Wheatgrass</td>
<td>Citana</td>
<td>0.5</td>
<td>5</td>
</tr>
<tr>
<td>Elymus trachycaulus</td>
<td>Slender Wheatgrass</td>
<td>Primar</td>
<td>0.5</td>
<td>5</td>
</tr>
<tr>
<td>Nasella viridula</td>
<td>Green Needlegrass</td>
<td>LoDorm</td>
<td>0.8</td>
<td>5</td>
</tr>
<tr>
<td>Panicum virgatum</td>
<td>Switchgrass</td>
<td>Nebraska 28</td>
<td>0.6</td>
<td>15</td>
</tr>
<tr>
<td>Poa secunda</td>
<td>Sandberg Bluegrass</td>
<td>Native - VNS†</td>
<td>0.5</td>
<td>5</td>
</tr>
<tr>
<td>Sporobolus cryptandrus</td>
<td>Sand Dropseed</td>
<td>Native - VNS†</td>
<td>0.01</td>
<td>4</td>
</tr>
<tr>
<td>Stipa comata</td>
<td>Needleandthread Grass</td>
<td>Native - VNS†</td>
<td>0.7</td>
<td>5</td>
</tr>
<tr>
<td>Grass species subtotal</td>
<td></td>
<td></td>
<td>9.41</td>
<td>95</td>
</tr>
<tr>
<td><strong>FORBS (Wildflowers)</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleome serrulata</td>
<td>Rocky Mountain Beeplant</td>
<td>Native - VNS†</td>
<td>0.1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Coreopsis tinctoria</td>
<td>Plains coreopsis</td>
<td>Native - VNS†</td>
<td>0.01</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Erysimum asperum</td>
<td>Western Wallflower</td>
<td>Native - VNS†</td>
<td>0.01</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Gaillardia aristata</td>
<td>Blanketflower</td>
<td>Native - VNS†</td>
<td>0.1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Liatris punctata</td>
<td>Blazing-star</td>
<td>Native - VNS†</td>
<td>0.1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Linum lewisii</td>
<td>Blue Flax</td>
<td>Native - VNS†</td>
<td>0.03</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Oenothera villosa</td>
<td>Tall Eveningprimrose</td>
<td>Native - VNS†</td>
<td>0.01</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Penstemon angustifolia</td>
<td>Narrow-leaf Penstemon</td>
<td>Native - VNS†</td>
<td>0.02</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Ratibida columnaris</td>
<td>Prairie Coneflower</td>
<td>Native - VNS†</td>
<td>0.3</td>
<td>&lt;1</td>
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</table>
### Mix Design 2 - Non-saline Upland Seed Mix For Shoulder Areas

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Variety</th>
<th>lbs PLS /acre*</th>
<th>% of mix**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GRASSES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bouteloua curtipendula</td>
<td>Sideoats Grama</td>
<td>Vaughn</td>
<td>0.8</td>
<td>10</td>
</tr>
<tr>
<td>Bouteloua gracilis</td>
<td>Blue Grama</td>
<td>Bad River</td>
<td>0.05</td>
<td>2.5</td>
</tr>
<tr>
<td>Bouteloua gracilis</td>
<td>Blue Grama</td>
<td>Hachita</td>
<td>0.05</td>
<td>2.5</td>
</tr>
<tr>
<td>Buchloe dactyloides</td>
<td>Buffalograss</td>
<td>Cody</td>
<td>0.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Buchloe dactyloides</td>
<td>Buffalograss</td>
<td>Native -VNS†</td>
<td>0.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Distichlis spicata v. stricta</td>
<td>Inland Saltgrass</td>
<td>Native -VNS†</td>
<td>0.3</td>
<td>5</td>
</tr>
<tr>
<td>Elymus lanceolatus v. lanceolatus</td>
<td>Thickspike Wheatgrass</td>
<td>Critana</td>
<td>1.1</td>
<td>11</td>
</tr>
<tr>
<td>Elymus lanceolatus v. psammophilus</td>
<td>Streambank Wheatgrass</td>
<td>Sodar</td>
<td>1.0</td>
<td>10</td>
</tr>
<tr>
<td>Elymus trachycaulus</td>
<td>Slender Wheatgrass</td>
<td>Primar0.5</td>
<td>0.5</td>
<td>5</td>
</tr>
<tr>
<td>Nasella viridula</td>
<td>Green Needlegrass</td>
<td>LoDorm</td>
<td>0.8</td>
<td>5</td>
</tr>
<tr>
<td>Pascopyrum smithii</td>
<td>Western Wheatgrass</td>
<td>Arriba</td>
<td>3.6</td>
<td>25</td>
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<tr>
<td>Poa secunda</td>
<td>Sandberg Bluegrass</td>
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<td>0.5</td>
<td>5</td>
</tr>
<tr>
<td>Sporobolus cryptandrus</td>
<td>Sand Dropseed</td>
<td>Native -VNS†</td>
<td>0.01</td>
<td>4</td>
</tr>
<tr>
<td>Stipa comata</td>
<td>Needleandthread Grass</td>
<td>Native -VNS†</td>
<td>0.7</td>
<td>5</td>
</tr>
<tr>
<td><strong>Grass species subtotal</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL PLS RATE</strong></td>
<td></td>
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<td>10.8</td>
<td>100</td>
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### Mix Design 3 - Saline Upland Area Mix, Denver International Airport

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Variety</th>
<th>lbs PLS /acre*</th>
<th>% of mix**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GRASSES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buchloe dactyloides</td>
<td>Buffalograss</td>
<td>Cody</td>
<td>1.4</td>
<td>5</td>
</tr>
<tr>
<td>Buchloe dactyloides</td>
<td>Buffalograss</td>
<td>Native</td>
<td>1.4</td>
<td>5</td>
</tr>
</tbody>
</table>
### Mix Design 4 - Non-saline Wetland Mix, Denver International Airport

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Variety</th>
<th>lbs PLS /acre*</th>
<th>% of mix**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GRASSES &amp; GRASSLIKES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beckmannia syzigachne</td>
<td>American Sloughgrass</td>
<td>Native</td>
<td>0.2</td>
<td>10</td>
</tr>
<tr>
<td>Glyceria grandis</td>
<td>Giant Mannagrass</td>
<td>Native</td>
<td>0.1</td>
<td>10</td>
</tr>
<tr>
<td>Juncus torreyii</td>
<td>Torrey Bulrush</td>
<td>Native</td>
<td>0.01</td>
<td>5</td>
</tr>
<tr>
<td>Carex nebrascensis</td>
<td>Nebraska sedge</td>
<td>Native</td>
<td>0.3</td>
<td>10</td>
</tr>
<tr>
<td>Carex utriculata</td>
<td>Beaked Sedge</td>
<td>Native</td>
<td>0.4</td>
<td>10</td>
</tr>
<tr>
<td>Elymus canadensis</td>
<td>Canada Wildrye</td>
<td>Native</td>
<td>2.0</td>
<td>15</td>
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<tr>
<td>Leymus triticoides</td>
<td>Creeping Wildrye</td>
<td>Native</td>
<td>4.6</td>
<td>15</td>
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<tr>
<td>Juncus balticus</td>
<td>Baltic Rush</td>
<td>Native</td>
<td>0.01</td>
<td>10</td>
</tr>
<tr>
<td>Schoenoplectus validus</td>
<td>Softstem Bulrush</td>
<td>Native</td>
<td>0.4</td>
<td>15</td>
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<tr>
<td><strong>TOTAL PLS RATE</strong></td>
<td></td>
<td></td>
<td>8.0</td>
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</tbody>
</table>

### Mix Design 5 - Saline Wetland Seed Mix, Denver International Airport

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Variety</th>
<th>lbs PLS /acre*</th>
<th>% of mix**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GRASSES &amp; GRASSLIKES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scirpus paludosus (S. maritimus)</td>
<td>Alkali Bulrush</td>
<td>Native</td>
<td>3.9</td>
<td>50</td>
</tr>
<tr>
<td>Puccinellia airoides</td>
<td>Nuttall Alkaligrass</td>
<td>Native</td>
<td>0.33</td>
<td>25</td>
</tr>
</tbody>
</table>
# Mix Design 6 - Pond Bottom Seed Mix

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Variety</th>
<th>lbs PLS /acre*</th>
<th>% of mix**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GRASSES &amp; GRASSLIKES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distichlis spicata v. stricta</td>
<td>Inland Saltgrass</td>
<td>Native-VNS†</td>
<td>0.3</td>
<td>10</td>
</tr>
<tr>
<td>Juncus balticus</td>
<td>Baltic Rush</td>
<td>Native-VNS†</td>
<td>0.02</td>
<td>10</td>
</tr>
<tr>
<td>Panicum virgatum</td>
<td>Switchgrass</td>
<td>Nebraska 28</td>
<td>0.4</td>
<td>10</td>
</tr>
<tr>
<td>Pascopyrum smithii</td>
<td>Western Wheatgrass</td>
<td>Arriba</td>
<td>7.9</td>
<td>50</td>
</tr>
<tr>
<td>Puccinellia airoides</td>
<td>Nuttall Alkaligrass</td>
<td>Native-VNS†</td>
<td>0.06</td>
<td>10</td>
</tr>
<tr>
<td>Scirpus paludosus (S. maritimus)</td>
<td>Alkali Bulrush</td>
<td>Native-VNS†</td>
<td>1.1</td>
<td>10</td>
</tr>
<tr>
<td><strong>TOTAL PLS RATE</strong></td>
<td></td>
<td></td>
<td>9.8</td>
<td>100</td>
</tr>
</tbody>
</table>

* PLS means Pure Live Seed; rates shown are for drill seeding, if broadcast, rates should be doubled.

** Percent by seed number

*** Wetland mixes to be used only where wetland hydrology exists. Check with DIA Environmental Services.

† VNS = Variety Not Stated

Seeding shall be performed during the period between spring thaw and July 1 or between October 15 and the freezing of the ground.

## 901-2.2 FERTILIZER

Fertilizer shall be standard commercial fertilizers supplied separately or in mixtures containing the percentages of total nitrogen, available phosphoric acid, and water-soluble potash. They shall be applied at the rate and to the depth specified, and shall meet the requirements of applicable state laws. They shall be furnished in standard containers with name, weight, and guaranteed analysis of contents clearly marked thereon. No cyanamide compounds or hydrated lime shall be permitted in mixed fertilizers.

The fertilizers may be supplied in one of the following forms:

- **a.** A dry, free-flowing fertilizer suitable for application by a common fertilizer spreader;

- **b.** A finely-ground fertilizer soluble in water, suitable for application by power sprayers; or
c. A granular or pellet form suitable for application by blower equipment.

Fertilizers shall be a commercial fertilizer and shall be spread at the rate which is determined by the seeding contractor to allow for proper vegetative growth.

901-2.3 SOIL FOR REPAIRS. The soil for fill and topsoiling of areas to be repaired shall be at least of equal quality to that which exists in areas adjacent to the area to be repaired. The soil shall be relatively free from large stones, roots, stumps, or other materials that will interfere with subsequent sowing of seed, compacting, and establishing turf, and shall be approved by the DEN Project Manager before being placed.

CONSTRUCTION METHODS

901-3.1 ADVANCE PREPARATION AND CLEANUP. After grading of areas has been completed and before applying fertilizer and ground limestone, areas to be seeded shall be raked or otherwise cleared of stones larger than 2 inches (50 mm) in any diameter, sticks, stumps, and other debris that might interfere with sowing of seed, growth of grasses, or subsequent maintenance of grass-covered areas. If any damage by erosion or other causes has occurred after the completion of grading and before beginning the application of fertilizer and ground limestone, the Contractor shall repair such damage include filling gullies, smoothing irregularities, and repairing other incidental damage.

An area to be seeded shall be considered a satisfactory seedbed without additional treatment if it has recently been thoroughly loosened and worked to a depth of not less than 5 inches (125 mm) as a result of grading operations and, if immediately prior to seeding, the top 3 inches (75 mm) of soil is loose, friable, reasonably free from large clods, rocks, large roots, or other undesirable matter, and if shaped to the required grade.

When the area to be seeded is sparsely sodded, weedy, barren and unworked, or packed and hard, any grass and weeds shall first be cut or otherwise satisfactorily disposed of, and the soil then scarified or otherwise loosened to a depth not less than 5 inches (125 mm). Clods shall be broken and the top 3 inches (75 mm) of soil shall be worked into a satisfactory seedbed by discing, or by use of cultipackers, rollers, drags, harrows, or other appropriate means.

901-3.2 SEEDING. Seeding shall be accomplished by drill seeding or by broadcast seeding.

If drill seeding is used, the seed drill will be equipped with three seed boxes including one for large smooth seed, one for fluffy seed (with picker wheels to prevent bridging), and one for small smooth seed. Furrow spacing may vary between 7 and 9 inches (175 to 225 mm). Drill will have double disc furrow openers and functioning depth bands set to plant at ½ inch (12 mm) depth. Drill will have either packer wheels or drag chains. Grain drills are NOT acceptable. Seeder-cultipackers are also not acceptable.

If broadcast seeding is used, soil surface will be roughened IMMEDIATELY prior to seeding using a toothed-type harrow. Seed will be spread by hand or by cyclonic spreader at a rate
TWICE that specified for drill seeding in Tables 901-1 and 901-2. Immediately following seeding, the treated area will be harrowed with a tooth-type harrow to cover the seed. Sufficient passes will be made to assure that seed is covered to a depth of at least ¼ inch. Brush or chain-link drags are not acceptable for this purpose.

901-3.3 MAINTENANCE OF SEEDED AREAS. The Contractor shall protect seeded areas against traffic or other use by warning signs or barricades, as approved by the DEN Project Manager. Surfaces gullied or otherwise damaged following seeding shall be repaired by regrading and reseeding as directed. The Contractor shall mow, water as directed, and otherwise maintain seeded areas in a satisfactory condition until final inspection and acceptance of the work.

When either the dry or wet application method outlined above is used for work done out of season, it will be required that the Contractor establish a good stand of grass of uniform color and density to the satisfaction of the DEN Project Manager. A grass stand shall be considered adequate when bare spots are one square foot (0.01 sq m) or less, randomly dispersed, and do not exceed 3% of the area seeded.

Alternatively, a two-year warranty period may be established after which re-vegetation requirements associated with construction projects as regulated by the National Pollutant Discharge Elimination System (NPDES) stormwater program and managed by the Colorado Department of Public Health and Environment (CDPHE) would be implemented. Permanent stabilization is defined by CDPHE and in this specification as return of ground cover (cover of live plants including weeds plus that of litter (detached dead plant parts) and standing dead plant material) equal to or greater than 70% of that present previous to disturbance. Inasmuch as total ground cover in this area prior to disturbance is often in the range of 70 to 80%, meaning that 70% of these levels is about 50 to 55%, a single standard of 50% total ground cover will be used. That is, to be regarded as stabilized, project areas must demonstrate 50% ground cover (by visual estimate). In other words no more than 50% of the surface may be exposed soil. Areas with bare soil in excess of 50% may be no larger than 1000 sq.ft. as determined by the DEN Project Manager.

If, at the time when the contract has been otherwise completed it is not possible to make a determination of the adequacy of the re-vegetation, payment for the unaccepted portions of the areas will be withheld until such time as these requirements have been met.

METHOD OF MEASUREMENT

901-4.1 The quantity of seeding to be paid for shall be the number of units [1,000 square feet (sq m)] [acre (sq m)] measured on the ground surface, completed and accepted.

BASIS OF PAYMENT

901-5.1 901-5.1 Payment shall be made at the contract unit price per [1,000 square feet (sq m)] [acre (sq m)] or fraction thereof, which price and payment shall be full compensation for furnishing and placing all material and for all labor, equipment, tools, and incidentals necessary to complete the work prescribed in this item.
Payment will be made under:

Item 901-5.1  Seeding – per [1,000 square feet (sq m)] [acre (sq m)]

**MATERIAL REQUIREMENTS**

ASTM C602  Standard Specification for Agricultural Liming Materials
ASTM D977  Standard Specification for Emulsified Asphalt
FED SPEC  JJJ-S-181, Federal Specification, Seeds, Agricultural

**ATTACHMENT 901-A  NOXIOUS WEED SPECIES AS PER COLORADO WEED ACT**

**LIST A NOXIOUS WEED SPECIES**

- African rue (Peganum harmala)
- Camelthorn (Alhagi pseudalhagi)
- Common crupina (Crupina vulgaris)
- Cypress spurge (Euphorbia cyparissias)
- Dyer's woad (Isatis tinctoria)
- Giant salvinia (Salvinia molesta)
- Hydrilla (Hydrilla verticillata)
- Meadow knapweed (Centaurea pratensis)
- Mediterranean sage (Salvia aethiopis)
- Medusahead (Taeniatherum caput-medusae)
- Myrtle spurge (Euphorbia myrsinites)
- Purple loosestrife (Lythrum salicaria)
- Rush skeletonweed (Chondrilla juncea)
- Sericea lespedeza (Lespedeza cuneata)
- Squarrose knapweed (Centaurea virgata)
- Tansy ragwort (Senecio jacobaea)
- Yellow starthistle (Centaurea solstitialis)

**LIST B NOXIOUS WEED SPECIES**

- Absinth wormwood (Artemisia absinthium)
- Black henbane (Hyoscyamus niger)
- Bouncingbet (Saponaria officinalis)
Bull thistle (Cirsium vulgare)
Canada thistle (Cirsium arvense)
Chinese clematis (Clematis orientalis)
Common tansy (Tanacetum vulgare)
Common teasel (Dipsacus fullonum)
Corn chamomile (Anthemis arvensis)
Cutleaf teasel (Dipsacus lacinatus)
Dalmatian toadflax, broad-leaved (Linaria dalmatica)
Dalmatian toadflax, narrow-leaved (Linaria genistifolia)
Dame's rocket (Hesperis matronalis)
Diffuse knapweed (Centaurea diffusa)
Eurasian watermilfoil (Myriophyllum spicatum)
Hoary cress (Cardaria draba)
Houndstongue (Cynoglossum officinale)
Leafy spurge (Euphorbia esula)
Mayweed chamomile (Anthemis cotula)
Moth mullein (Verbascum blattaria)
Musk thistle (Carduus nutans)
Orange hawkweed (Hieracium aurantiacum)
Oxeye daisy (Chrysanthemum leucanthemum)
Perennial pepperweed (Lepidium latifolium)
Plumeless thistle (Carduus acanthoides)
Quackgrass (Elytrigia repens)
Redstem filaree (Erodium cicutarium)
Russian knapweed (Acroptilon repens)
Russian-olive (Elaeagnus angustifolia)
Salt cedar (Tamarix chinensis, T.parviflora, and T. ramosissima)
Scentless chamomile (Matricaria perforata)
Scotch thistle (Onopordum acanthium)
Scotch thistle (Onopordum tauricum)
Spotted knapweed (Centaurea maculosa)
Spurred anoda (Anoda cristata)
Sulfur cinquefoil (Potentilla recta)
Venice mallow (Hibiscus trionum)
Wild caraway (Carum carvi)
Yellow nutsedge (Cyperus esculentus)
Yellow toadflax (Linaria vulgaris)

LIST C NOXIOUS WEED SPECIES

Chicory (Cichorium intybus)
Common burdock (Arctium minus)
Common mullein (Verbascum thapsus)
Common St. Johnswort (Hypericum perforatum)
Downy brome (Bromus tectorum)
Field bindweed (Convolvulus arvensis)
Halogeton (Halogeton glomeratus)
Johnsongrass (Sorghum halepense)
Jointed goatgrass (Aegilops cylindrica)
Perennial sowthistle (Sonchus arvensis)
Poison hemlock (Conium maculatum)
Puncturevine (Tribulus terrestris)
Velvetleaf (Abutilon theophrasti)
Wild proso millet (Panicum miliaceum)

END OF ITEM T-901
ITEM T-905 TOPSOILING

DESCRIPTION

905-1.1 This item shall consist of preparing the ground surface for topsoil application, removing topsoil from designated stockpiles or areas to be stripped on the site or from approved sources off the site, and placing and spreading the topsoil on prepared areas in accordance with this specification at the locations shown on the plans or as directed by the DEN Project Manager.

MATERIALS

905-2.1 TOPSOIL. Topsoil shall be the surface layer of soil with no admixture of refuse or any material toxic to plant growth, and it shall be reasonably free from subsoil and stumps, roots, brush, stones (2 inches (50 mm) or more in diameter), and clay lumps or similar objects. Brush and other vegetation that will not be incorporated with the soil during handling operations shall be cut and removed. Heavy sod or other cover, which cannot be incorporated into the topsoil by discing or other means, shall be removed. The topsoil or soil mixture, unless otherwise specified or approved, shall have a pH range of approximately 7.6 pH to 8.0 pH, when tested in accordance with the methods of testing of the Association of Official Agricultural Chemists in effect on the date of invitation of bids. The organic content shall be not less than 1% nor more than 10% as determined by the wet-combustion method (chromic acid reduction). Soil textures (USDA) suitable for re-vegetation include Sandy Loam, Loam, Silt Loam, Clay Loam, Sandy Clay Loam, Silty Clay Loam, and Loamy Sand.

When topsoil is imported to the site, it shall meet the following criteria:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture</td>
<td>Sandy Loam, Loam, Silt Loam, Clay Loam, Sandy Clay Loam, Silty Clay Loam, Loamy Sand</td>
<td>Silty Clay, Clay, Sandy Clay, Sand, Silt</td>
</tr>
<tr>
<td>Soil Reaction</td>
<td>pH 5.0 to 8.0</td>
<td>&lt; 5.0 or &gt; 8.0</td>
</tr>
<tr>
<td>Salinity (mmhos/cm)</td>
<td>&lt; or = 4.0</td>
<td>&gt; 4.0</td>
</tr>
<tr>
<td>Organic Matter (%)</td>
<td>&gt; or = 1.0</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Coarse Fragment Content (%)*</td>
<td>&lt; or = 20</td>
<td>&gt; 20</td>
</tr>
</tbody>
</table>
* Percent by weight of particles > 2 mm diameter (ie. gravels; cobbles and boulders excluded by provisions of 901-3.2)

Natural topsoil may be amended by the Contractor with approved materials and methods to meet the above specifications.

905-2.2 INSPECTION AND TESTS. Within 10 days following acceptance of the bid, the DEN Project Manager shall be notified of the source of topsoil to be furnished by the Contractor. The topsoil shall be inspected to determine if the selected soil meets the requirements specified and to determine the depth to which stripping will be permitted. At this time, the Contractor may be required to take representative soil samples from several locations within the area under consideration and to the proposed stripping depths, for testing purposes as specified in paragraph 905-2.1.

CONSTRUCTION METHODS

905-3.1 GENERAL. Areas to be topsoiled shall be shown on the plans. If topsoil is available on the site, the location of the stockpiles or areas to be stripped of topsoil and the stripping depths shall be shown on the plans.

Suitable equipment necessary for proper preparation and treatment of the ground surface, stripping of topsoil, and for the handling and placing of all required materials shall be on hand, in good condition, and approved by the DEN Project Manager before the various operations are started.

905-3.2 PREPARING THE GROUND SURFACE. Immediately prior to dumping and spreading the topsoil on any area, the surface shall be loosened by discs or spike-tooth harrows, or by other means approved by the DEN Project Manager, to a minimum depth of 18 inches (45 cm) minus the specified depth of the topsoil. If, for example, the topsoil depth is six inches (as would be typical) the ripping need only go to 12 inches (30 cm). In FAA determined safety areas on the shoulders of taxiways, runways or ramps where only 6 inches of ripping is allowed, the total depth of loosened material including topsoil will be 6 inches.

The surface of the area to be topsoiled shall be cleared of all stones larger than 2 inches (50 mm) in any diameter and all litter or other material which may be detrimental to proper bonding, the rise of capillary moisture, or the proper growth of the desired planting. Limited areas, as shown on the plans, which are too compact to respond to these operations shall receive special scarification.

Grades on the area to be topsoiled, which have been established by others as shown on the plans, shall be maintained in a true and even condition. Where grades have not been established, the areas shall be smooth-graded and the surface left at the prescribed grades in an even and compacted condition to prevent the formation of low places or pockets where water will stand.

905-3.3 OBTAINING TOPSOIL. Prior to the stripping of topsoil from designated areas, any vegetation, briars, stumps and large roots, rubbish or stones found on such areas,
which may interfere with subsequent operations, shall be removed using methods approved by the DEN Project Manager. Heavy sod or other cover, which cannot be incorporated into the topsoil by discing or other means shall be removed.

When suitable topsoil is available on the site, the Contractor shall remove this material from the designated areas and to the depth as directed by the DEN Project Manager. The topsoil shall be spread on areas already tilled and smooth-graded, or stockpiled in areas approved by the DEN Project Manager. Any topsoil stockpiled by the Contractor shall be rehandled and placed without additional compensation. Any topsoil that has been stockpiled on the site by others, and is required for topsoiling purposes, shall be removed and placed by the Contractor. The sites of all stockpiles and areas adjacent thereto which have been disturbed by the Contractor shall be graded if required and put into a condition acceptable for seeding.

When suitable topsoil is secured off the airport site, the Contractor shall locate and obtain the supply, subject to the approval of the DEN Project Manager. The Contractor shall notify the DEN Project Manager sufficiently in advance of operations in order that necessary measurements and tests can be made. The Contractor shall remove the topsoil from approved areas and to the depth as directed. The topsoil shall be hauled to the site of the work and placed for spreading, or spread as required. Any topsoil hauled to the site of the work and stockpiled shall be rehandled and placed without additional compensation.

**a. Topsoil Amendments.** If topsoil is unavailable or of such poor quality that available materials need supplementary organic matter, then soil amendments shall be used. The soil amendment shall consist of composted biosolids or composted manure, or other organic soil amendment product approved by the Project Manager.

Organic amendment comprised of composted biosolids shall comply with all requirements of U.S. EPA’s biosolids regulations.

Organic amendment comprised of composted manure shall be produced as follows:

1. Compost organic amendment (cow or sheep manure) for 90 to 120 days. Certification must be provided to prove the product has gone through this process.
2. Eradicate harmful pathogens including coliform bacteria.
3. Create a carbon to nitrogen ratio of 15:1 to 25:1.
4. Contain no solid particle greater than ½ inch diameter.
5. Have a non-offensive smell similar to fresh turned soil.
6. Contain no significant level of dirt, soil, or chemical preservatives and contain a maximum of 30 percent composted plant residue.
7. Have a Ph after composting between 6 and 8 with an organic matter content of at least 20 percent.
(8) Contain soluble salts not greater than 5mmhos/cm.

(9) Produced by aerobic decomposition.

(10) Processed at a consistent temperature of 140 degrees F or greater.

A Certificate of Compliance shall be provided to the Project Manager to verify the organic matter content, pH, and carbon matter to nitrogen ratio, and salt levels (by electrical conductivity mmhos/cm).

If organic amendment is not available, a natural trace mineral, carbon, and humic acid based granular soil conditioner may be used (such as Menefee Humate, or approved equal).

The proposed soil amendment shall be submitted to the Project Manager for his work approval as a part of the Common Excavation Plan. The soil amendment plan shall be based on soil samples obtained from the topsoil removed and stockpiled and shall be formulated to develop a suitable seed bed at least as suitable as those areas where topsoil is placed.

b. Topsoil Plan. The Contractor shall prepare a Topsoil Plan which shall include but not be limited to the following items:

(1) Location and quantity of topsoil stockpiles available for the project.

(2) Location and quantity of topsoil available from borrow areas.

(3) Location and quantity of topsoil required for all areas to be topsoiled within project limits.

(4) Identification of and plan for removal of all undesirable materials such as weeds, trash, debris, etc., before actual stripping commences.

(5) Haul routes, schedules, utility conflicts, and other Topsoil Plan features by the Project Manager.

905-3.4 STOCKPILING. Stockpiled side slopes shall not exceed 3:1. All stockpiles and adjacent areas that have been disturbed by the Contractor shall be graded, topsoiled if necessary, ripped and seeded in accordance with Sections T-901 and T-908. Whenever it is practical, topsoil shall be hauled directly from the salvage site to the placement site to avoid double handling.

A sufficient amount of topsoil for the entire project including shrinkage and waste shall be set aside before any quality topsoil material is used for purposes other than topsoiling.

905-3.5 PLACING TOPSOIL. The topsoil shall be evenly spread on the prepared areas that have been left roughened to prevent topsoil layer slippage. Topsoil shall be placed to an average depth of six (6) inches, where the subsoil is suitable according to the following.

Subsoil Suitability criteria are as follows:
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Reaction</td>
<td>pH 5.0 to 8.7</td>
<td>&lt; 5.0 or &gt;8.7</td>
</tr>
<tr>
<td>Salinity (mmhos/cm)</td>
<td>&lt; or = 7.0</td>
<td>&gt; 7.0</td>
</tr>
</tbody>
</table>

Where the subsoil does not meet the above suitability criteria, then the topsoil depth shall be 15 inches, or the Contractor shall apply soil amendments in order to bring brine soils within acceptance criteria.

Spreading shall not be done when the ground or topsoil is frozen, excessively wet, or otherwise in a condition detrimental to the work. Spreading shall be carried on so that turfing operations can proceed with a minimum of soil preparation or tilling.

After spreading, any large, stiff clods and hard lumps shall be broken with a pulverizer or by other effective means, and all stones or rocks (2 inches (50 mm) or more in diameter), roots, litter, or any foreign matter shall be raked up and disposed of by the Contractor. after spreading is completed, the topsoil shall be satisfactorily compacted by rolling with a cultipacker or by other means approved by the DEN Project Manager. The compacted topsoil surface shall conform to the required lines, grades, and cross-sections. Any topsoil or other dirt falling upon pavements as a result of hauling or handling of topsoil shall be promptly removed.

**905-3.6 VERIFICATION OF TOPSOIL THICKNESS.** The contractor shall be required to provide depth measurements for every 5,000 square yards of topsoil placed to a minimum of 6 inch depth of topsoil. To test the depth of topsoil, the redressed areas will be divided into 10 acre plots. Within each plot, at least ten randomly selected locations will be sampled for topsoil depth before seedbed preparation. More than 90% of the samples must have a depth equal to or greater than the specified design depth. If this criterion is not met, the contractor will redress the plot. Topsoil shall be added as necessary to provide and maintain the minimum 6 inches of topsoil through the contract and maintenance period.

**905-3.7 TOLERANCES.** The surface of the finished topsoil surface shall be of such smoothness that it will not vary more than plus 0.10’ to minus 0.10’ from true grade as shown on the Contract Drawings. Any deviation in excess of this amount shall be corrected by loosening, adding and removing materials, and reshaping.

**METHOD OF MEASUREMENT**

**905-4.1** Topsoil obtained on the site shall be measured by the number of cubic yards (cubic meters) of topsoil measured in its original position and stripped or excavated. Topsoil stockpiled by others and removed for topsoiling by the Contractor shall be measured by the number of cubic yards (cubic meters) of topsoil measured in the stockpile. Topsoil shall be measured by volume in cubic yards (cubic meters) computed by the method of end areas.

**905-4.2** Topsoil obtained off the site shall be measured by the number of cubic yards (cubic meters) of topsoil measured in its original position and stripped or excavated. Topsoil shall be measured by volume in cubic yards (meters) computed by the method of end areas.
BASIS OF PAYMENT

905-5.1 Payment will be made at the contract unit price per cubic yard (cubic meter) for topsoiling (obtained on the site). This price shall be full compensation for furnishing all materials and for all preparation, placing, and spreading of the materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

905-5.2 Payment will be made at the contract unit price per cubic yard (cubic meter) for topsoiling (obtained off the site). This price shall be full compensation for furnishing all materials and for all preparation, placing, and spreading of the materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item T-905-5.1 Topsoiling (Obtained on Site or Removed from Stockpile – per cubic yard (cubic meter)

Item T-905-5.2 Topsoiling (Furnished from Off the Site) – per cubic yard (cubic meter)

TESTING MATERIALS

ASTM C117 Materials Finer than 75 μm (No. 200) Sieve in Mineral Aggregates by Washing

END OF ITEM T-905
ITEM T-908 MULCHING

DESCRIPTION

908-1.1 This item shall consist of furnishing, hauling, placing, and securing mulch on surfaces indicated on the plans or designated by the DEN Project Manager.

MATERIALS

908-2.1 MULCH MATERIAL. Acceptable mulch shall be the materials listed below or any approved locally available material that is similar to those specified. Mulch shall be free from noxious weeds, mold, and other deleterious materials. Mulch materials, which contain matured seed of species that would volunteer and be detrimental to the proposed overseeding, or to surrounding farm land, will not be acceptable. Straw or other mulch material which is fresh and/or excessively brittle, or which is in such an advanced stage of decomposition as to smother or retard the planted grass, will not be acceptable.

a. Wood-fiber Mulch. Wood fiber mulch must be virgin long-fiber material. Wood fiber shall be absent of materials toxic to plant growth. Wood chips are not acceptable.

b. Matting.

(1) Covering. Covering shall consist of blankets with close weave mesh and nettings with open weave mesh made of various materials as specified herein.

(2) Blankets and nettings shall be biodegradable, non-toxic to vegetation or germination of seed, and shall not be toxic or injurious to humans.

(a) Excelsior. Excelsior soil retention covering shall be biodegradable as follows:

The blanket shall consist of a machine produced mat of curled wood excelsior of 80 percent, 6 inch or longer fiber length with a consistent thickness of fibers evenly distributed over the entire area of the blanket. The top side of the blanket shall be covered with a biodegradable netting, manufactured from a jute or other biodegradable material and stitched on 2 inch centers the entire width of the blanket.

Dimensions: 48" by 180' or 96" by 90'
Roll Weight: 0.9 to 1.1 pounds per sq. yd.

(b) Soil Retention Blanket (Coconut). Soil Retention Blanket (Coconut) shall be a machine produced mat consisting of 100 percent coconut fiber. The
blanket shall be of consistent thickness with the coconut fiber evenly distributed over the entire area of the mat. The blanket shall be sewn together with biodegradable thread.

Material requirements:

Coconut Fiber Content: 100%, 0.50 to 0.60 lb. per sq. yd.

Netting: Both sides, biodegradable 9.3 lbs. per 1000 sq. ft.

Thread: Biodegradable

Roll Width: 6.5 to 7.5 feet

Roll Length: 83.5 to 110 feet

Area Covered by One Roll: 60 to 80 sq. yds.

(c) Soil Retention Blanket (Straw). Soil Retention Blanket (Straw) shall be a machine produced mat consisting of 100 percent agricultural straw. The blanket shall be of consistent thickness with the straw evenly distributed over the entire area of the mat. The blanket shall be covered on the top side with biodegradable netting having an approximate 5/8 inch x 5/8 inch to ½ inch x ½ inch mesh and on the bottom with biodegradable netting with an approximate ¼ inch x ¼ inch to ½ inch x ½ inch mesh. The blanket shall be sewn together with biodegradable thread.

Material requirements:

Straw Content: 100%, 0.50 lb. per sq. yd.

Netting: Bottom side biodegradable, 9. lbs. per 1000 sq. ft.;

Netting: Top side biodegradable, 9.3 lbs. per 1000 sq. ft.

Thread: Biodegradable

Roll Width: 6.5 to 7.5 feet

Roll Length: 83.5 to 110 feet

Area Covered by One Roll: 60 to 80 sq. yds

A sample of the soil retention blanket (straw) shall be submitted at least 2 weeks in advance of its use on the project for approval by the Project Manager.

(d) Soil Retention Blanket (Straw and Coconut). Soil Retention Blanket (Straw/Coconut) shall be a machine produced mat consisting of 70 percent agricultural straw and 30 percent coconut fiber. The blanket shall be of consistent thickness with the straw and coconut fiber evenly distributed over the entire area of the mat. The blanket shall be covered on the top side with polypropylene netting having an approximate 5/8 inch x 5/8 inch mesh and on the bottom with polypropylene netting with an approximate ¼ inch x ¼ inch to ½ inch x ½ inch mesh. The blanket shall be sewn together with cotton, biodegradable or photodegradable thread.

Material requirements:
Straw Content: 70% 0.35 lb. per sq. yd.
Coconut Fiber Content: 30% 0.15 lb. per sq. yd.
Netting: Bottom side biodegradable, 9.3 lbs. per 1000 sq. ft.;
Netting: Top side biodegradable, 9.3 lbs. per 1000 sq. ft.
Thread: Cotton, biodegradable
Roll Width: 6.5 to 7.5 feet
Roll Length: 83.5 to 110 feet
Area Covered by One Roll: 60 to 80 sq. yds

A sample of the soil retention blanket (straw and coconut) shall be submitted at least 2 weeks in advance of its use on the project for approval by the Project Manager.

(3) Pins and Staples. Pins and staples shall be made of wire 0.162 inch or larger in diameter. “U” shaped staples shall have legs 8 inches long and a 1 inch crown. “T” shaped pins shall not be used

c. Tackifier. Material for mulch tackifier shall consist of a free-flowing, organic, 100% all natural starch polymer, applied in a slurry with water and wood fiber

d. Stubble Mulch. Stubble mulch is the holdover debris of stems and leaves left from a small grain crop; these can function as mulch for a permanent seeding. One of the crop species below is used to establish a cover and mulch that functions as a standing mulch for subsequent seeding. NOTE: when using these species, the crop must be mowed to produce stubble prior to producing seed.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Date of crop planting</th>
<th>Date of permanent cover seeding</th>
<th>Rate (lb PLS/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat/Wheatgrass Hybrid (&quot;ReGreen&quot;™)</td>
<td>April 1 to May 15</td>
<td>Next fall*</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>August 15 to October 1</td>
<td></td>
<td>35</td>
</tr>
<tr>
<td>Oats</td>
<td>April 1 to May 15</td>
<td>Next fall</td>
<td>30</td>
</tr>
<tr>
<td>Winter Wheat/Triticale</td>
<td>August 1 to October 1</td>
<td>Next fall</td>
<td>25</td>
</tr>
<tr>
<td>Spring Barley</td>
<td>April 1 to May 15</td>
<td>Next fall</td>
<td>30</td>
</tr>
<tr>
<td>Long-season (southern) Grain Sorghum</td>
<td>May 15 to July 15</td>
<td>Next fall</td>
<td>30</td>
</tr>
</tbody>
</table>

*Next fall after cover crop seeding

908-2.2 INSPECTION. The DEN Project Manager shall be notified of sources and quantities of mulch materials available and the Contractor shall furnish him with representative samples of the materials to be used 30 days before delivery to the project.
These samples may be used as standards with the approval of the DEN Project Manager and any materials brought on the site that do not meet these standards shall be rejected.

908-2.3 STORAGE. The Contractor shall store mulch with protection from weather or other conditions that would damage or impact the effectiveness of the product.

CONSTRUCTION METHODS

908-3.1 MULCHING. Before spreading mulch, all large clods, stumps, stones, brush, roots, and other foreign material shall be removed from the area to be mulched. Mulch shall be applied immediately after seeding.

908-3.2 HYDRAULIC MULCHING. Wood-fiber mulch and tackifier shall be added to water to form homogeneous slurry. The operator shall apply the slurry mixture uniformly over the designated seeded area via spraying.

Hydraulic mulching shall not be done in the presence of free surface water.

Mixing procedure for the hydraulic mulch and tackifier mixture shall be as follows:

a. Fill tank with water approximately ¼ full.

b. Continue filling while agitating with engine at full rpm.

c. Pour tackifier, at a moderate rate, directly into area of greatest turbulence.

d. With the recommended amount of tackifier in solution, add wood-fiber mulch. Do not add fertilizer.

Apply the mulch and tackifier mixture at the following rate:

<table>
<thead>
<tr>
<th>Wood-Fiber Mulch</th>
<th>Tackifier</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 lbs./Acre</td>
<td>90 lbs./Acre</td>
<td>3000 gal./Acre</td>
</tr>
</tbody>
</table>

After the hydraulic mulch is applied, foot traffic on the mulch surface should be minimized. Mulch once mixed with water and tackifier shall be used within 4 hours. Unused mulch mixture shall be promptly removed from the site.

908-3.3 MATTING. All erosion control matting installed will be keyed into the ground surface along all exposed (non-overlapping) edges. Keying will consist placing the edge across a six-inch deep trench and backfilling over the mat to the original ground surface level.

a. Excelsior. The area to be covered shall be prepared, fertilized, and seeded, before the blanket is placed. When the blanket is unrolled, the netting shall be on top and the fibers shall be in contact with the soil. In ditches, blankets shall be unrolled in the direction of the flow of water. The end of the upstream blanket shall overlap the buried end of the downstream blanket a maximum of 8 inches and a minimum of 4 inches, forming a junction.
slot. This junction slot shall be stapled across at 8 inch intervals. Adjoining blankets (side by side) shall be offset 8 inches from center of ditch and overlapped a minimum of 4 inches. Six staples shall be used across the start of each roll, at 4 foot intervals, alternating the center row so that the staples form an “X” pattern. A common row of staples shall be used on adjoining blankets.

b. **Soil Retention Blanket (Coconut), (Straw), and (Straw and Coconut).** The area to be covered with Soil Retention Blanket (Coconut), (Straw), and (Straw and Coconut) shall be properly prepared, fertilized, and seeded before the blanket is placed. When the blanket is unrolled, the heavyweight polypropylene netting shall be on top and the lightweight polypropylene netting shall be in contact with the soil. In ditches and on slopes, blankets shall be unrolled in the direction of the flow of water. Installation shall be in accordance with manufacturer’s recommendations. A representative of the manufacturer shall be present to give instruction during the installation of the soil retention blanket.

The blanket shall be placed smoothly but loosely on the soil surface without stretching. The upslope end shall be buried in a trench 6 inches wide by 6 inches deep beyond the crest of the slope to avoid undercutting. For slope applications, there shall be a 6 inch overlap wherever one roll of blanket ends and another begins with the uphill blanket placed of top on the blanket on the downhill side. There shall be a 4 inch overlap wherever two widths of blanket are applied side by side. Insert staples in a pattern according to the manufacturer’s recommendation at approximately two staples per square yard.

At terminal ends, and every 35 feet, Soil Retention Blanket (Coconut), (Straw), and (Straw/Coconut) placed in ditches shall be buried in a trench approximately 6 inches deep by 6 inches wide. Before backfilling, staples shall be placed across the width of the trench spaced at 6 inches on center in a zigzag pattern. The trench shall then be backfilled to grade and compacted by foot tamping.

### 908-3.4 CARE AND REPAIR.

a. The Contractor shall care for the mulched areas until final acceptance of the project. Care shall consist of providing protection against traffic or other use by placing warning signs, as approved by the DEN Project Manager, and erecting any barricades that may be shown on the plans before or immediately after mulching has been completed on the designated areas.

b. The Contractor shall be required to repair or replace any mulch that is defective or becomes damaged until the project is finally accepted. When, in the judgment of the DEN Project Manager, such defects or damages are the result of poor workmanship or failure to meet the requirements of the specifications, the cost of the necessary repairs or replacement shall be borne by the Contractor.

### METHOD OF MEASUREMENT

908-4.1 Mulching shall be measured in square yards (square meters) on the basis of the actual surface area acceptably mulched.
BASIS OF PAYMENT

908-5.1 Payment will be made at the contract unit price per square yard (square meter) for mulching. The price shall be full compensation for furnishing all materials and for placing and anchoring the materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item T-908-5.1 Mulching – per square yard (square meter)

MATERIAL REQUIREMENTS

ASTM D977 Standard Specification for Emulsified Asphalt

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 DEN Project 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:

d. Return to Owner or remove from the site, as directed by the DEN Project 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 DEN Project 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 DEN Project 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 DEN Project 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 DEN Project Manager informed of scheduled work which will affect existing equipment and operations. Minimum 10 working days advance notice shall be given to the DEN Project 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 DEN Project 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 DEN Project 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 DEN Project 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 DEN Project 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 DEN Project 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 DEN Project 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 DEN Project 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 DEN Project 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 DEN Project Manager. The directions of the DEN Project 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 DEN Project 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 DEN Project 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 DEN Project Manager will furnish a newly printed set of blue line 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 DEN Project Manager upon completion. This work shall be completed and accepted by the DEN Project Manager before approval of final payment. The Contractor shall include complete as-built 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 DEN Project 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 DEN Project 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 DEN Project 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 project 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 DEN Project 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 DEN Project 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 DEN Project 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 DEN Project 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 DEN Project Manager. Final payment will be withheld until receipt of the warranty by the DEN Project 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, per Section 014310.

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 DEN Project 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 DEN Project 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 DEN Project 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 DEN Project 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 Project 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 DEN Project Manager.

METHOD OF MEASUREMENT

100-4.1 Refer to Appendix A for Method of Measurement.

BASIS OF PAYMENT

100-5.1 Refer to Appendix A for Basis of Payment

MATERIAL REQUIREMENTS
<table>
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<th>Code</th>
<th>Description</th>
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<tr>
<td>AC 150/5370-2</td>
<td>Operational Safety on Airports During Construction</td>
</tr>
<tr>
<td>AC 150/5370-10</td>
<td>Standards for Specifying Construction of Airports</td>
</tr>
<tr>
<td>MIL-P-152388</td>
<td>Wash Primer Specification</td>
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<tr>
<td>TT-P-641F</td>
<td>Type II, Base Paint, Zinc-Rich</td>
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**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 incidental necessary to place the cable in operating condition as a completed unit to the satisfaction of the DEN Project Manager. 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. Requirements and payment for trenching and backfilling for the installation of underground conduit and duct banks is in Item L-110, Airport Underground Electrical Duct Banks and Conduits.

This item shall also include removal of existing wire and/or cable when applicable. Any wire or cable, installed in duct or conduit, which is abandoned by the project, shall be completely removed, and all scrap shall be full compensation to the Contractor for removing said excess wire or cable unless a cable removal item is included in the proposal.

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 DEN Project Manager.

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 DEN Project Manager) 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 DEN Project Manager 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 DEN Project Manager, to determine compliance with the plans and specifications per Item L-100, Lighting and Electrical Work. The Contractor’s submittals shall be neatly bound in a properly sized 3-ring binder, tabbed by specification section. The DEN Project Manager 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 twenty-four (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.

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, 19 strand, #8 American wire gauge AWG, L-824 Type C, 5,000 volts, nonshielded, with cross-linked polyethylene insulation. The L-824 return conductor shall be black with white stripe. The white stripe shall be printed at the wire manufacturing facility prior to installing on reels. The return wire shall be installed from the last fixture (light, sign, etc.) in the series circuit to the regulator in the vault or selector switch.

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 Underwriters Laboratories (UL) Standard 44 and shall be type XHHW2, 90°C. Conductors for parallel (voltage) circuits shall be sized 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 90°C, XHHW-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 XHHW-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 Documents.

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. 6 AWG bare, 7-stranded copper wire for counterpoise and/or No. 6 AWG insulated stranded for ground wire per ASTM B3 and ASTM B8, and shall be bare copper wire per ASTM B33. See AC 150/5340-30 for additional details about counterpoise and ground wire types and installation. For voltage powered circuits, the equipment ground conductor shall be minimum No. 6 AWG, 600V rated, Type XHHW insulated, green color, stranded copper equipment ground conductor. Counterpoise conductor is incidental to other work.

Ground rods shall be copper-clad steel. The ground rods shall be of the length and diameter specified on the plans, but in no case be less than 10 feet (2.54 m) long and 3/4 inch (19 mm) 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. Figure 3 of AC 150/5345-26, Specification for L-823 Plug and Receptacle, Cable Connectors, employing connector kits, is acceptable for field attachment to single conductor cable when provided with an integral boot to seal the joint between the male and female connectors. It shall be the Contractor’s responsibility to determine the outside diameter of the cable to be spliced and to furnish appropriately sized connector kits and/or adapters and heat shrink tubing with integral sealant. Prior to final cable termination, new connectors shall be installed on all cable new and existing.


d. The Taped or Heat-Shrinked Splice. Not Used.

e. Low Voltage Power and Lighting Cable Splice shall be made using a compression sleeve applied with a tool which must be fully activated before it can be removed. The splice shall be insulated to at least the voltage rating of the cable. The
insulating material shall be heavy wall polyolefin tubing with a minimum expanded to recovered ratio of 3:1, meeting UL 486D, and including a thermoplastic hot-melt adhesive material factory applied to the inside of the tubing. The splice shall have two layers of heat shrinkable tubing. The first layer shall be the length of the compression sleeve. The length of the second heat shrinkable tubing shall extend at least 10 diameters to both sides of the compression sleeve.

Insulated spring wire connectors with plastic caps for copper conductor splices and taps may be used for 10 AWG and smaller conductor connections installed above ground in enclosures. The connectors shall be rated for 600 volts AC maximum (building wire) and 1,000 volts AC maximum (luminaires and fixtures).

In all the above cases, connections of cable conductors shall be made using crimp connectors using a crimping tool designed to make a complete crimp before the tool can be removed. All L-823/L-824 splices and terminations shall be made per the manufacturer’s recommendations and listings.

All connections of counterpoise, grounding conductors and ground rods shall be made by the exothermic process or approved equivalent, except that a light base ground clamp connector shall be used for attachment to the light base. See AC 150/5340-30 for additional information about methods of attaching a ground to a galvanized light base. All exothermic connections shall be made per the manufacturer’s recommendations and listings.

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 DEN Project Manager 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 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.

108-2.7 TAPE. Electrical tapes shall be Scotch™ Electrical Tapes –Scotch™ 88 (1-1/2 inch (38 mm) wide) and Scotch™ 130C© linerless rubber splicing tape (2-inch (50 mm) wide), as manufactured by the Minnesota Mining and Manufacturing Company (3M™), or an approved equivalent.

108-2.8 ELECTRICAL COATING. Scotchkote™ as manufactured by 3M™, or an approved equivalent.

108-2.9 EXISTING CIRCUITS. Whenever the scope of work requires connection to an existing circuit, the circuit’s insulation resistance shall be tested, in the presence of the DEN Project Manager. The test shall be performed per this item and prior to any activity that will affect the respective circuit. Where portions of the existing cable is to be put back in service, the existing cable portion shall be tested at the time the circuit is broken and again
just prior to connecting to the new portion. This will verify any degradation of the existing portion, if any, during the time of construction. The Contractor shall record the results on forms acceptable to the DEN Project Manager. The forms shall include all information required per section 108-3.10 Testing and be submitted within 48 hours of the test. When the work affecting the circuit is complete, the circuit’s insulation resistance shall be checked again, in the presence of the DEN Project Manager. The Contractor shall record the results on forms acceptable to the DEN Project Manager. The second reading shall be equal to or greater than the first reading or the Contractor shall make the necessary repairs to the 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.

CONSTRUCTION METHODS

108-3.1 GENERAL. The Contractor shall install the specified cable at the approximate locations indicated on the plans. Wherever possible, cable shall be run without splices, from connection to connection. For installation requirements of cables in conduit, refer to Item L-110, Airport Underground Electrical Duct Banks and Conduits.

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 DEN Project Manager 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. Connectors are required on all cables in all light base cans that are used only as pull-cans (with no fixture.) L-823 connectors are required in sign circuits passing through a manhole or base can that has a stub out for a future sign. L-823 connectors shall be installed so a portion of the loop can be bypassed. See connector details (the female connector shall be on the regulator supply cable.). Cable circuit identification markers shall be installed on both sides of the L-823 connectors installed or at least once in each access point where L-823 connectors are not installed.

Provide not less than 3 feet (1 m) or more than 4 feet (1.2 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 3 feet (1 m) vertically above the top of the access structure. Provide 6 feet of slack from conduit entrance where primary cable passes through empty light bases, junction boxes, and access structures to allow for future connections, or as designated by the DEN Project Manager. In manholes the cable shall have enough slack to neatly install on racking system with connectors on highest rack possible and two-foot drip loops at corners of the manhole. Approved cable ties shall be used to separate each circuit and support the cables on the arms of the racking system. Each circuit shall be tie wrapped every two feet between conduit entrance and exit.
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.

Where existing cable and new cable will be connected, install a new connector on both the existing and new cable, as stated above.

The return splice shall be as-built. When installation allows, splice the return conductor in base cans with identification numbers ending with “0” or “5” only.

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 DEN Project Manager 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 DEN Project Manager prior to any cable installation. If required by the DEN Project Manager, pulling tension values for cable pulls shall be monitored by a dynamometer in the presence of the DEN Project Manager. Cable pull tensions shall be recorded by the Contractor and reviewed by the DEN Project Manager. 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 DEN Project Manager, 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.

Any wire lost or that is found not to have sufficient insulation resistance, as indicated in Section 108-3.10, Testing, shall require all conductors within a conduit to be removed and replaced at the expense of the Contractor.

108-3.3 INSTALLATION OF DIRECT-BURIED CABLE IN TRENCHES. Direct-buried cable shall not be allowed.

108-3.4 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 DEN Project Manager.

b. Field-attached Plug-in Splices. Submit for review and acceptance the tools proposed for stripping and crimping of cable connections. 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 (38 mm) 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.

c. Factory-Molded Plug-in Splices. These shall be made by plugging directly into mating connectors. In all cases, the joint where the connectors come together shall be 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, except when connecting to an elevated fixture.

d. Taped or Heat-Shrunked Splices. Not Used.

108-3.5 BARE COUNTERPOISE WIRE INSTALLATION FOR LIGHTNING PROTECTION AND GROUNDING. If shown on the plans or included in the job specifications, bare stranded #6 AWG copper counterpoise wire shall be installed for lightning protection of the underground cables. The method of lightning protection for the airfield lighting circuit shall be:

a. Equipotential. – Used for areas that have high rates of lightning strikes. This is where the counterpoise is bonded to the light base (edge lights included) and rebar cage. Counterpoise size shall be as indicated in the Contract drawings.

Counterpoise wire shall be installed in the same trench for the entire length of conduits and duct banks that are installed to contain airfield cables.

For raceways installed under pavement; for raceways not installed adjacent to the full strength pavement edge; for fixtures installed in full strength pavement and shoulder pavement, the counterpoise conductor shall be centered over the raceway to be protected as described below.
The counterpoise conductor shall be installed no less than 4 inches (100 mm) above the raceway to be protected.

The counterpoise conductor shall be bonded to each metallic light base.

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.

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.

A ground rod shall be installed at and securely attached to each light fixture base and to all metal surfaces at junction/access structures via #6 AWG wire.

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.

108.3.6 **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 cone of protection measured 22-1/2 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.

108.3.7 **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.

108.3.8 **EXOTHERMIC BONDING.** Bonding of counterpoise wire shall be by the exothermic welding process. Only personnel experienced in and regularly engaged in this type of work shall make these connections.

Contractor shall demonstrate to the satisfaction of the DEN Project Manager, 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 also 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™ Scotchkote™, or approved equivalent, or coated with coal tar Bitumastic® material to prevent surface exposure to corrosive soil or moisture.

108-3.9 LOW VOLTAGE POWER CABLE. All cables shall be tagged in each equipment enclosure. Tags shall be attached to cables immediately after installation.

Tags shall be large enough to accommodate all required lettering (1/4-inch high and appropriate width). All characters shall be legibly written on material which is not affected by water, solvents or other severe conditions. Tags shall be non-metallic and attached securely with non-metallic fastener.

Marking of the tags shall consist of an abbreviation of the name of the facility or facilities served by the cable and panelboard branch circuit connected to.

Wires for three phase circuits shall be color coded by insulation or with a band of tape at each termination and at the entrance and exit from each conduit, box, or other device. The wire tag shall also indicate the phase by letter A (black), B (red), C (blue), neutral (white) for 120/208 volts or A (brown), B (orange), C (yellow) and neutral (natural gray) for 277/480 volt circuits. Ground wires shall have green insulation or be bare copper. Tape shall not be used to identify neutral or ground wires unless specifically permitted by the NEC.

Where more than one identical cable is used to serve the same facility, they may be bundled under one tag, unless the plans state otherwise.

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 DEN Project Manager. The Contractor shall demonstrate the electrical characteristics to the satisfaction of the DEN Project Manager. 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 DEN Project Manager for approval. Earth resistance testing results shall be recorded on an approved form
and testing shall be performed in the presence of the DEN Project Manager. 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 DEN Project Manager shall approve of the test method selected. All such testing shall be at the sole expense of the Contractor.

Prior to starting any work, the Contractor shall megger the cable(s) of all airfield lighting circuits in the presence of the DEN Project Manager. The results of the tests shall be recorded by the Contractor and certified by the DEN Project Manager. At completion of the project, all of the circuits shall be meggered and the results compared to the initial test. If the final megger results are lower than the initial readings, the Contractor shall verify that the circuits were not affected by construction. Otherwise the Contractor shall replace and/or repair the circuit(s) at no additional cost to the Sponsor. This does not relieve the Contractor from demonstrating that all new work performed meets the requirements stated below.

After installation, the Contractor shall test and demonstrate to the satisfaction of the DEN Project Manager 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 1,000 megohms when tested at 1,000VDC applied for 3 minutes.

f. Prior to energizing, all building service cables, feeders to and/or from transformers, switchboards, panelboards are to be tested with a 1000 VDC insulation megohm meter to determine insulation resistance levels. Test cables one minute with a 1000VDC volt megohm meter or as recommended by the manufacturer. All field test data is to be recorded, corrected to a baseline temperature and furnished to the DEN Project Manager. A test is to include meggering for three minutes between conductors and between each conductor and ground. Cables are to be meggered after installation with cables disconnected at both ends. Insulation test values shall meet or exceed the values given below.

<table>
<thead>
<tr>
<th>Conductor Size (AWG or CMIL)</th>
<th>Resistance (Megohms – 1,000 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-8</td>
<td>200</td>
</tr>
<tr>
<td>6-2/0</td>
<td>100</td>
</tr>
<tr>
<td>3/0-500</td>
<td>100</td>
</tr>
</tbody>
</table>
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 25 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 DEN Project Manager prior to performing the testing.

The contact resistance to earth shall not exceed 5 OHMS for the entire counterpoise system. If this occurs provide the location and resistance value to the DEN Project Manager. The DEN Project Manager shall direct corrective action when needed to reduce the resistance to 5 OHMS or less.

j. That all counterpoise is continuous as determined by the resistive value (size and length) as routed with the circuit conductors. (light can to light can, manhole to light can, manhole to manhole, light can to ground rod).

Two copies of tabulated results of all cable tests performed shall be supplied by the Contractor to the Engineer. Where connecting new cable to existing cable, ground 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 or counterpoise wire installed in trench, duct bank or conduit shall be measured by the number of linear feet (meters) 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 Ground rods shall be measured by each installed complete.

**BASIS OF PAYMENT**

108-5.1 Payment will be made at the contract unit price for cable and bare counterpoise wire installed in trench, or cable and equipment ground installed in duct bank or conduit, in place by the Contractor and accepted by the DEN Project Manager. 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-108-5.1 Trenching for direct-buried cable, 18 inch minimum depth – per linear foot (meter)

Item L-108-5.3 No. 6 AWG, Solid, Bare Counterpoise Wire, Installed in Trench, Above the Duct Bank or Conduit, Including Ground Rods and Ground Connectors - per linear foot (meter)

Item L-108-5.4 No. 6 AWG, [Bare] [Insulated], Stranded Equipment Ground, Installed in Duct Bank or Conduit – per linear foot (meter)

MATERIAL REQUIREMENTS

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-59544 Cable and Wire, Electrical (Power, Fixed Installation)

Commercial Item Description A-A-55809 Insulation Tape, Electrical, Pressure-Sensitive Adhesive, Plastic

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

FED SPEC J-C-30 Cable and Wire, Electrical (Power, Fixed Installation)

MIL-I-24391 Insulation Tape, Electrical, Plastic, Pressure Sensitive

REFERENCE DOCUMENTS

NFPA-70 National Electrical Code (NEC)

NFPA-780 Standard for the Installation of Lightning Protection Systems
MIL-S-23586F Performance Specification: Sealing Compound (with Accelerator), Silicone Rubber, Electrical


END OF ITEM L-108
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 DEN Project Manager, 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 DEN Project Manager.

b. Manufacturer’s certifications shall not relieve the Contractor of the responsibility to provide materials per these specifications and acceptable to the DEN Project Manager. Materials supplied and/or installed that do not comply with these specifications shall be removed, when directed by the DEN Project Manager 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 DEN Project Manager 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 DEN Project Manager, to determine compliance with the plans and specifications per Item L-100, Lighting and Electrical Work. The Contractor’s submittals shall be neatly bound in a properly sized 3-ring binder, tabbed by specification section. The DEN Project Manager 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 mil 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.

110-2.3 PLASTIC CONDUIT. Plastic conduit and fittings shall conform to the following requirements:

- UL 514B covers Conduit fittings all types, classes 1 thru 3 and 6 thru 10.
- UL 514C covers Nonmetallic boxes all types, Class 5 junction box and cover in plastic (PVC).
- UL 651 covers Rigid PVC Conduit, types I and II, Class 4.
- UL 651A covers 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 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 conform to Item P-610, Structural Portland Cement Concrete, using 1 inch maximum size coarse aggregate. Where reinforced duct banks are specified, reinforcing steel shall conform to ASTM A615 Grade 60. Concrete and reinforcing steel are incidental to the respective pay item of which they are a component part.

110-2.7 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.

110-2.8 DETECTABLE WARNING TAPE. Plastic, detectable, American Public Works Association (APWA) Red (electrical power lines, cables, conduit and lighting cable) 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 DEN Project Manager 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. No duct bank shall be less than 36 inches (0.6 m) or underground conduit less than 24 inches (0.6 m) below finished grade. Where under pavement, the top of the duct bank shall not be less than 24 inches (0.6 m) below the subgrade.
The Contractor shall mandrel each individual conduit whether the conduit is direct-buried or part of a duct bank. An approved rubber gasket mandrel, not more than 1/4 inch (6 mm) smaller than the bore of the conduit shall have a rope secured at both ends and be pulled through each conduit. The Contractor shall cease pulling the mandrel through existing duct if the mandrel does not move freely and notify the Engineer of the condition. The mandrel shall have a 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 DEN Project Manager 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 mm) sieve. Flowable backfill may alternatively be used. The Contractor shall ascertain the type of soil or rock to be excavated before bidding. All such rock removal shall be performed and paid for under Item P-152, Excavation, Subgrade and Embankment.

Underground electrical warning (caution) tape shall be installed in the trench above all underground duct banks and conduits in unpaved areas. The Contractor shall submit a sample of the proposed warning tape for approval by the DEN Project Manager. 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 DEN Project Manager, the unsuitable material shall be removed per Item P-152 and replaced with suitable material. Alternatively, additional duct bank supports that are adequate and stable shall be installed, as approved by the DEN Project Manager.

All excavation shall be unclassified and shall be considered incidental to the respective L-110 pay item of which it is a component part. Dewatering necessary for duct installation, erosion and turbidity control, per Federal, state, and local requirements is incidental to its respective pay item as a part of Item L-110. The cost of all excavation regardless of type of material encountered, shall be included in the unit price bid for the L-110 Item.

Unless otherwise specified, excavated materials that are deemed by the DEN Project Manager 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 DEN Project Manager 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 DEN Project Manager, 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 24 inches (0.6 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 36 inches (1m) below finished grade where installed in unpaved areas.

Unless otherwise shown on the plans, duct banks under paved areas shall extend at least 5 feet (1.5 m) beyond the edges of the pavement or 5 feet (1.5 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 inch (75 mm) apart (measured from outside wall to outside wall). All such multiple conduits shall be placed using conduit spacers applicable to the type of conduit. As the conduit laying progresses, concrete 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 DEN Project Manager 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 DEN Project Manager 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 DEN Project Manager.

110-3.3 CONDUITS WITHOUT CONCRETE ENCASEMENT. Trenches for single-conduit lines shall not be less than 6 inches (150 mm) nor more than 12 inches (300 mm) wide. The trench for 2 or more conduits installed at the same level shall be proportionately wider. Trench bottoms for conduits without concrete encasement shall be made to conform accurately to grade so as to provide uniform support for the conduit along its entire length.

Unless otherwise shown on plans, conduits shall be installed so that the tops of all conduits within the Airport’s secured area where trespassing is prohibited are at least 36 inches (1 m) below the finished grade. Conduits outside the Airport’s secured area shall be installed so that the tops of the conduits are at least 24 inches (60 cm) below the finished grade per National Electric Code (NEC), Table 300.5.

When two or more individual conduits intended to carry conductors of equivalent voltage insulation rating are installed in the same trench without concrete encasement, they shall be spaced not less than 3 inches (75 mm) apart (measured from outside wall to outside wall) in a horizontal direction and not less than 6 inches (150 mm) apart in a vertical direction. Where two or more individual conduits intended to carry conductors of differing voltage insulation rating are installed in the same trench without concrete encasement, they shall be placed not less than 3 inches (75 mm) apart (measured from outside wall to outside wall) in a horizontal direction and lot less than 6 inches (150 mm) apart in a vertical direction.

Trenches shall be opened the complete length between normal termination points before conduit is installed so that if any unforeseen obstructions are encountered, proper provisions can be made to avoid them.

Conduits 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 while backfilling. 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 DEN Project Manager for review prior to use. Backfill of trenches shall be P-153 flowable backfill material with red dye to within 10 inches (250 mm) of finished grade to allow for growth of vegetation.

110-3.4 MARKERS. The location of each end 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 and has a 12-inch (300 mm) diameter by 12-inch (300 mm) deep anchor attached 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.

The Contractor shall impress the word “DUCT” on each marker slab. Impression of letters shall be done in a manner, approved by the DEN Project Manager, for a neat, professional appearance. All letters and words must be neatly stenciled. 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.

110-3.5 BACKFILLING FOR CONDUITS. P-153 flowable backfill with red dye shall be used to backfill all trenches for ducts encased in concrete under new concrete or asphalt pavement. Under pavement the flowable backfill shall be level with the subgrade. The Contractor shall reference section P-153 of these specifications, and shall be responsible for material and placement.

Any excess excavated material shall be removed and disposed of per instructions issued by the DEN Project Manager.

110-3.6 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 fertilizing, seeding, and mulching 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.

METHOD OF MEASUREMENT

110-4.1 Underground conduits and duct banks shall be measured by the linear feet (meter) of conduits and duct banks installed, including encasement, locator tape, trenching and backfill with designated material, 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 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.

Payment will be made under:

Item L-110-5.1 [Concrete Encased] [Non-Encased] Electrical Duct Bank, [# and Size] – per linear foot (meter)

Item L-110-5.2 [Concrete Encased] [Non-Encased] Electrical Conduit, [# and Size] – per linear foot (meter)

**MATERIAL REQUIREMENTS**

Advisory Circular (AC) 150/5340-30
Design and Installation Details for Airport Visual Aids

AC 150/5345-53 Airport Lighting Equipment Certification Program

ASTM A615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

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/ft³(2,700 kN-m/m³))

ASTM D2167 Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

ASTM D2922 Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

NFPA-70 National Electrical Code (NEC)

Underwriters Laboratories Standard 6
Electrical Rigid Metal Conduit - Steel

Underwriters Laboratories Standard 514B
Conduit, Tubing, and Cable Fittings

Underwriters Laboratories Standard 514C
Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers

Underwriters Laboratories Standard 1242
Electrical Intermediate Metal Conduit Steel

Underwriters Laboratories Standard 651
Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings

Underwriters Laboratories Standard 651A
Type EB and A Rigid PVC Conduit and HDPE Conduit
END OF ITEM L-110
ITEM L-125 AIRPORT LIGHTING SYSTEMS

DESCRIPTION

125-1.1 GENERAL. This item shall consist of airport lighting systems furnished and installed in accordance with this specification, any referenced specifications, and the applicable Federal Aviation Administration (FAA) Advisory Circulars. The systems shall be installed at the locations and in accordance with the dimensions, layout, design, and details shown in the drawings. This item shall include furnishing and installing all lights, signs, transformers, bases, mounting assemblies, base plates, adapter rings, concrete work, sealing filler, adhesive sealant, cable connections, all lamps, ground rod and inspection pits, testing of the installation and all incidentals and appurtenances necessary to place the systems in operation as completed units to the satisfaction of the DEN Project Manager. The Contractor shall not place an order for any electrical, lighting, or signing material until specific approval is received from the DEN Project Manager for each order on an individual basis.

125-1.2 REFERENCED MATERIALS. Additional details pertaining to specific systems covered in this item are contained in the Advisory Circulars (ACs) (latest editions) and Engineering Briefs (EBs) (latest editions) listed below:

150/5340-1 Standards for Airport Markings
150/5340-18 Standards for Airport Sign Systems
150/5340-26 Maintenance of Airport Visual Aid Facilities
150/5340-30 Design and Installation Details for Airport Visual Aids
150/5345-7 Specification for L-824 underground Electrical Cable for Airport Lighting Circuits.
150/5345-26 Specification for L-823 Plug and Receptacle, Cable Connectors
150/5345-42 Specification for Airport Light Bases, Transformer Housings, Junction Boxes, and Accessories
150/5345-43 Specification for Obstruction Lighting Equipment
150/5345-44 Specification for Taxiway and Runway Signs
150/5345-46 Specification for Runway and Taxiway Light Fixtures
150/5345-47 Specification for Series to Series Isolation Transformers for Airport Lighting Systems
150/5345-53 Airport Lighting Equipment Certification Program
EB 67 Light Sources Other Than Incandescent and Xenon for Airport and Obstruction Lighting Fixtures
EB 83 In-Pavement Light Fixture Bolts

The Contractor is responsible for using the latest edition of the referenced FAA Advisory Circulars and Engineering Briefs.

125-1.3 SUBMITTALS. Submittals shall comply with Item L-100, Lighting and Electrical Work. Shop drawings of each airfield lighting component, indicating FAA approval, shall be submitted for approval and be approved prior to ordering any materials for this section. This submittal shall include the proposed method of installation for all airfield lighting components. The data submitted shall be sufficient, in the opinion of the DEN Project Manager, to determine compliance with the contract documents. The Contractors submittals shall be submitted to the DEN Project Manager within 30 days of the first Notice To Proceed. Submittals shall include as a minimum the following data:

a. Safety precautions used while maintaining the equipment.

b. Theory of circuit and system operation.

c. Complete schematic and interconnecting wiring diagrams.

d. Complete parts list with each circuit component keyed to designations assigned on schematics and wiring diagrams. Complete information shall be given for each part to permit ordering for replacement purposes. This information shall include the components rating, name of manufacturer and the manufacturer's part number.

e. Recommended preventative maintenance.

f. Troubleshooting procedures.

g. Physical characteristics (weight, size, mounting dimensions etc.).

h. Installation instructions/Details

i. Operating instructions.

j. There shall be no "Black Boxes" for which there are no schematic/wiring diagrams.

The method of binding and marking/labeling shall be submitted to the DEN Project Manager for approval.

125-1.4 QUALIFICATIONS. The DEN Project Manager reserves the right to reject any equipment which, in their opinion, does not meet the system design and the standards and codes specified herein.

MATERIALS
125-2.1 **GENERAL.** Airport lighting equipment and materials covered by FAA specifications shall have prior approval of the Federal Aviation Administration, Office of Airport Safety and Standards, Attention: AAS-100, 800 Independence Ave, SW, Washington, DC 20591, and shall be listed in Advisory Circular 150/5345-53, Latest Edition, Airport Lighting Equipment Certification Program, Appendix 3. All items that are FAA Testing Laboratory or DEN Project Manager approved at the time of bidding, which otherwise meet the project specifications, are acceptable.

All Light cans to be located in P-501 paving shall be shipped with plywood and target covers.

All other equipment and materials covered by other referenced specifications shall be subject to acceptance through the manufacturer's certification of compliance with the applicable specifications. The Contractor shall submit the manufacturer's certificates of compliance with the applicable equipment submittals.

Lists of the equipment and materials required for a particular system are contained in the applicable Advisory Circulars.

125-2.2 **GUARANTEES.** Except as modified below, all equipment and materials furnished and installed under this specification shall be guaranteed against defects in materials and workmanship for a period of twenty four (24) months from final acceptance by the DEN Project Manager. The defective materials and/or equipment shall be repaired or replaced, at the DEN Project Managers discretion, with no additional cost to the Owner.

The quartz lamp life, as rated by the FAA, shall be warranted for the specified number of hours. Should ten percent (10%) of the lamps fail prior to 70% of the rated life of the lamp, then the entire system using the failing lamp type shall be re-lamped, at the contractors expense, and the warranty time shall start over. At the Owners option, the Contractor may supply 100% spares.

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, DEN will coordinate directly with the manufacturer for fixture replacement or repair.

125-2.3 **BASIS OF DESIGN.** All airfield light fixtures provided for the project shall meet the requirements in AC 150/5345-46 (latest edition). The airfield lighting systems are designed using the below listed maximum fixture wattage. Approved airfield lighting fixtures with higher wattage are not permissible. In no case shall the Contractor be allowed to reduce the size of the constant current regulators or the power distribution systems. The series lighting circuits shall be 6.6 amps, except sign circuits which are 5.5 amps.

The Contractor shall remove and reinstall the existing quartz or LED fixture, where shown on the plans. A new isolation transformer shall be installed which is sized to meet the existing fixture power requirement.
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<td>Taxiway Centerline Light – Two-Lamp, Two-Circuit</td>
<td>2-45VA</td>
</tr>
<tr>
<td>L-852K(L)</td>
<td>Taxiway Centerline Light – Two-Lamp, Two-Circuit</td>
<td>2-45VA</td>
</tr>
<tr>
<td>L-852GS</td>
<td>Stop Bar/Runway Guard Light, Inset</td>
<td>2-105W</td>
</tr>
<tr>
<td>L-852T(L)</td>
<td>Taxiway Edge Light, Inset</td>
<td>45VA</td>
</tr>
<tr>
<td>L-858(L)</td>
<td>Guidance Sign, 1 Module, Size 3</td>
<td>90VA</td>
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<tr>
<td></td>
<td>Guidance Sign, 2 Module, Size 3</td>
<td>100VA</td>
</tr>
<tr>
<td></td>
<td>Guidance Sign, 3 Module, Size 3</td>
<td>105VA</td>
</tr>
<tr>
<td></td>
<td>Guidance Sign, 4 Module, Size 3</td>
<td>125VA</td>
</tr>
<tr>
<td></td>
<td>Runway Distance Remaining Sign, Size 4</td>
<td>95VA</td>
</tr>
<tr>
<td>L-861T</td>
<td>Taxiway Edge Light, Elevated</td>
<td>45W</td>
</tr>
<tr>
<td>L-862</td>
<td>Runway Edge Light, Elevated, Quartz Lamp</td>
<td>150W</td>
</tr>
<tr>
<td>L-862E</td>
<td>Runway Threshold Light, Elevated, Quartz Lamp</td>
<td>150W</td>
</tr>
<tr>
<td>L-862S</td>
<td>Runway Stop Bar Light, Elevated</td>
<td>150W</td>
</tr>
</tbody>
</table>

**125-2.4 TAXIWAY CENTERLINE LIGHT.** The taxiway centerline lights shall be L-852 type with LEDs. Fixtures shall be Class 2, Mode 1 (6.6A) Style 3 (“Flush”) and shall have a maximum height above finished pavement of 0.220”. LED fixtures shall have heater kits.

**125-2.5 RUNWAY CENTERLINE LIGHT.** The runway centerline lights shall be L-850A type with LEDs. Fixtures shall be Class 2, Mode 1 (6.6A) Style 3 (“Flush”) and shall have a maximum height above finished pavement of 0.220”. LED fixtures shall have heater kits.
125-2.6 RUNWAY TOUCHDOWN ZONE LIGHT. The runway touchdown zone lights shall be L-850B type with LEDs. Fixtures shall be Class 2, Mode 1 (6.6A) Style 3 ("Flush") and shall have a maximum height above finished pavement of 0.220”. LED fixtures shall have heater kits.

125-2.7 RUNWAY EDGE LIGHT. The runway edge lights shall be L-850C type with quartz lamps. Fixtures shall be Class 2, Mode 1 (6.6A) Style 3 ("Flush") and shall have a maximum height above finished pavement of 0.220”. Elevated runway edge light shall be L-862 quartz type and have an overall mounting height of 24”. The elevated edge light frangible coupling shall be a 2” – NPT with slotted threads for ease in removal of broken couplings mounted on a corten base plate with a neoprene gasket.

125-2.8 TAXIWAY EDGE LIGHT. The in-pavement taxiway edge lights shall be L-852T type with LEDs. Fixtures shall be Class 2, Mode 1 (6.6A) Style 3 ("Flush") and shall have a maximum height above finished pavement of 0.220”. Elevated taxiway edge light shall be L-861T quartz type and have an overall mounting height of 24”. The elevated edge light frangible coupling shall be a 1.5” – 12 NF with slotted threads for ease in removal of broken couplings. Mount fixtures on corten base plate with a neoprene gasket.

125-2.9 INSET STOP BAR / RUNWAY GUARD LIGHT. The in-pavement stop bar / runway guard light shall be L-852GS. Fixtures shall be Class 2, Mode 1 (6.6A) Style 3 ("Flush") two-circuit and shall have a maximum height above finished pavement of 0.220”. LED fixtures shall be provided if a certified fixture is available. LED fixtures shall have heater kits.

125-2.10 ELEVATED RUNWAY GUARD LIGHT. The runway guard lights shall be L-804 type with LEDs. Fixtures shall be Class 2, Mode 1 (6.6A), have an overall mounting height of 30”. The frangible coupling shall be a 2” – NPT. Mount fixture on a heavy (≥ 3/8” thick) base plate with a neoprene gasket.

125-2.11 ELEVATED STOP BAR LIGHT. The runway stop bar lights shall be L-862S type with 150W quartz lamps. Fixtures shall be Class 2, Mode 1 (6.6A), have an overall mounting height of 24”. The frangible coupling shall be a 2” – NPT. Mount fixture on a heavy (≥ 3/8” thick) base plate with a neoprene gasket.

125-2.12 GUIDANCE SIGN. Guidance signs shall meet the following requirements:

a. The guidance signs shall be L-858Y, R, or L internally lighted as indicated. The units shall be Size 3. The signs shall be Style 5 (1-step); Class 2 (-40 ⁰F to 131 ⁰F); and Mode 2 (withstand wind loads of 200 mph). They shall meet the requirements of FAA AC 150/5345-44 (latest edition).

b. Runway distance remaining signs shall be L-858B internally lighted as indicated. The units shall be Size 4; Style 5 (1-step); Class 2 (-40 ⁰F to 131 ⁰F); and Mode 2 (withstand wind loads of 200 mph). They shall meet the requirements of FAA AC 150/5345-44 (latest edition).
c. All signs supplied shall be furnished with an ON-OFF weatherproof toggle switch. The switch shall be located immediately adjacent to the load side of the L-823 disconnect plug. The switch shall be protected from driving rain and icing. The switch shall de-energize the sign so maintenance work can be performed.

125-2.13 LIGHT BASES. The light bases shall be L-867 type for the non-load bearing units and L-868 for the load bearing units. The sizes of the units shall be as shown on the drawings and in this specification. All light bases shall be Class IA (Galvanized Steel). All base cans shall include an identification marker installed on the opposite side of pavement marking. Each can shall have an internal and external grounding lug. The ground lug and the counterpoise connection must maintain electrical continuity. The flanges shall include an O-ring so that it is not excessively elevated above the channel. The spacer rings, adapter rings, and flange rings with pavement dams shall be galvanized steel.


For the 600 volt rated, 2-wire secondary conductors between the isolation transformers and fixtures, the connectors shall be in accordance with FAA AC 150/5345-26 (latest edition). Plug - Type II, Class A, Style 1. Receptacle—Type II, Class A, Style 7. Cable-2 conductor, 12 AWG, 600V rated insulation meeting FAA AC 150/5345-7.

125-2.15 CONNECTORS. Connectors shall comply with specification L-108.

125-2.16 ISOLATION TRANSFORMER. The isolation transformers shall be L-830, sized per the fixture manufacturer's recommendations.

Existing Crouse-Hinds sign L-830 transformers are 5.5 amps primary/ 6.2 amps secondary and wattage is sized per module length of sign.

125-2.17 LAMP. Where listed with the fixture types above, lamps shall be quartz of the size and type to provide distribution and minimum output requirements of isocandela curves shown for each size in AC 150/5345-46.

125-2.18 COLORED FILTERS. Colored filters, or colored lenses, to be used for Airfield Lighting Fixtures shall conform to the requirements of Specification SAE AS25050A, Type I and FAA Advisory Circulars.

125-2.19 TAPE. Electrical tapes shall meet the following requirements:

a. Vinyl. Premium grade 8.5 mil thick polyvinyl chloride, operating temperature range between 0⁰ to 200⁰F, breaking strength of 20lb/in, voltage rating of 600V, UV resistant, and meeting UL 510 requirements.

b. Rubber. Linerless, self-bonding, rated through 69kV, made of ethylene propylene rubber 30 mil thick, 250psi tensile strength, and emergency operating cable temperature of 266⁰F (130⁰C), and meets ASTM D4388.
125-2.20 **CONCRETE AND FLOWABLE BACKFILL.** Concrete for backfill and flowable backfill shall be in accordance with Item P-610 and P-153 respectively.

125-2.21 **CONDUIT.** Conduit shall comply with specification L-110.

125-2.22 **IDENTIFICATION/NUMBER MARKERS.** The engraved identification/number markers shall be as shown on the drawings. Engraved samples shall be submitted and approved prior to placement showing character depth and height being provided as well as physical properties of the marker. Payment for the markers shall be incidental to the item identified, except as indicated otherwise on the drawings.

125-2.23 **REINFORCING STEEL.** All reinforcing steel shall meet ASTM A615 grade 60.

125-2.24 **BOLTING HARDWARE.** Airfield bolting hardware, other than for mounting light fixtures to light bases, shall be stainless steel and meet FAA requirements. All bolts 1/4” and larger shall be hex head type. All bolts smaller than 1/4” trade size shall be recessed allen type. All bolted connections shall utilize an approved anti-rotational locking type device.

All bolts attaching equipment to a base can shall extend 1/2" minimum to 1-1/2” maximum beyond the base can flange ring and be continuously threaded. Bolts attaching equipment to base cans shall conform to Engineering Brief 83 or latest approved edition, such as approved dual coated bolts, with ceramic-metallic base coat/fluoropolymer top coat. Existing airfield lighting bolting hardware consists of steel and stainless steel bolts.

125-2.25 **ANTI-SEIZE COMPOUND.** Anti-seize compound shall have an oxidation inhibitor and electrical conductive properties. Do not use in conjunction with the ceramic-metallic/fluoropolymer coated bolts used for light fixture mounting.

125-2.26 **FILLERS AND ADHESIVES.** Joint sealing filler shall be FAA Type P-605 and adhesive compounds shall be FAA Type P-606.

125-2.27 **DELIVERY, STORAGE AND HANDLING.** Ship materials and equipment disassembled only to the extent necessary for reasons of shipping limitations, handling facilities, and to avoid damage during shipment. Maintain materials in new condition. This shall include the use of heat lamps, suitable coverings, indoor storage, etc. to properly protect the equipment and materials. Any equipment or materials, in the opinion of the DEN Project Manager, damaged during construction, handling, or storage periods shall be replaced by and at the cost of the Contractor.

125-2.28 **CEMENTITIOUS GROUT.** For use in the installation of ID markers. The cementitious grout shall be non-shrink, non-metallic and contain no chloride. When mixed to a fluid state, the typical compressive strength shall reach 5,800 psi in 28 days, and positive expansion. The grout shall meet the requirements of ASTM C1107 and ASTM C827.
125-2.29 MANHOLE CABLE RACKING. Manhole cable raking shall be heavy duty nonmetallic glass-reinforced nylon cable rack mounting and component parts. Minimum arm load rating shall be 250 lbs, measured one inch from the far end of an arm. Stanchions shall be either 24” or 36” long (approximate) as indicated on the drawings. Anchor bolts shall be 316 stainless steel, ½-13 drop in anchors with 316 stainless steel flat washers, and ½”-13 hex head cap screw. Rack arms shall be 6.5”, 11.25”, 20” long (approximate) as indicated on the drawings.

125-2.30 SILICONE GREASE. Designed for application on rubber O-rings installed between flange rings and light fixtures. The grease shall consist of a composition of polydimethylsiloxane and fumed silica. The grease shall be moisture resistant, prevent corrosion/oxidation, and have a service temperature range of -40°F to +400°F.

125-2.31 BASE CAN SEALANT. For application between the top of a load bearing base can and spacer rings and/or spacer rings and bottom of flange ring with pavement dam. The 100% silicone sealant shall be non-shrink.

CONSTRUCTION METHODS

125-3.1 INSTALLATION. All fixtures, signs, base cans, etc. shall be installed as shown on the drawings or approved shop drawings and in accordance with the applicable FAA Advisory Circular. Tolerances given in the FAA Advisory Circulars, these specifications, and the drawings shall not be exceeded. Where no tolerance is given, no deviation is permitted. Items not installed in accordance with the FAA Advisory Circulars, these specifications and drawings shall be replaced by and at the expense of the Contractor. In case of conflict between documents the most stringent shall apply.

Plywood and target covers are required on all light cans located in P-501 during shipping and paving. The tops of the light cans shall be surveyed to be located a minimum of 2-3/8” below the finished surface of the P-501. All concrete used for these items shall be completely consolidated and contain no voids. All exposed concrete shall be finished smooth with a steel trowel and broom finished. The finished pavement surface shall be protected from foreign substances which could cause staining, i.e. oil, etc. The Contractor shall immediately clean all spills and correct/clean any stained surfaces at the Contractor’s expense.

Assemble units and connect to the system in accordance with the manufacturer's recommendations and instructions.

An identification marker shall be installed with each fixture, sign, blank base can, etc. as shown in the drawings. Plastic circuit identification tags identifying each circuit shall be attached to each cable as shown in the drawings.

Provide slack in each cable in each base can from conduit entrance as required by Item L-108.
Galvanized surfaces that are damaged shall be repaired according to the manufacturer's recommendations, to the satisfaction of the DEN Project Manager. When the damage to a surface is ten percent or more of the total surface, the item shall be replaced at the Contractor's expense. Base cans that have been deformed will cause damage to the galvanizing and will be cause for removal and replacement at the Contractor’s expense.

Except where ceramic-metallic/flouropolymer coated bolts are being inserted, airfield lighting steel threaded connections, i.e. frangible couplings shall be coated with an approved anti-seize compound before being screwed together. No anti-seize compound shall be applied to the ceramic-metallic/flouropolymer coated bolts.

Apply base can sealant between the top of the base can and spacer rings and/or spacer rings and bottom of flange ring with pavement dam. Do not over apply such that the sealant is pressed onto the bolt holes. Apply silicone grease to the gasket O-ring or inside the flange ring with pavement dam. Application between the fixture and flange ring with pavement dam shall be dependent on the type of flange ring with pavement dam that is installed, verify application with DEN Project Manager prior to proceeding. Base can sealant shall not be applied between the fixture and the flange ring with pavement dam.

All damaged or incorrect ID markers shall be removed and replaced.

Where existing cable and new cable will be connected, install a new connector on the existing and new cable. Once the connection is made, all joints shall be wrapped as discussed in Specification L-108.

Reinforcing steel cages shall be assembled with tie wire. Reinforcing steel shall be installed true and plumb according to the dimensions and tolerances given on the Drawings. Welding is not acceptable.

If a PCC panel must be removed and replaced for any reason and the panel contains a light base(s), a new light base(s) shall be installed as part of the panel replacement at the Contractor’s expense.

Existing airfield lighting bolting hardware consists of either ceramic-metallic/flouropolymer coated bolts, stainless steel bolts, or carbon steel bolts. All bolts and lock washers removed by the Contractor shall be replaced with new SAE Grade 2 bolts with ceramic-metallic/flouropolymer coated bolts and new stainless steel lock washers. Any existing damage to existing equipment shall be documented and brought to the Project Manager’s attention prior to commencing work. Light fixture mounting bolts which are broken by the Contractor shall be repaired by the Contractor at no additional cost to the Airport. Broken bolts shall be repaired using a method approved by the Project Manager. The method shall include using an approved repair kit that fits within the fixture dam ring. Existing bolts shall be drilled out and tapped using the template to assure proper alignment of drill. Inserts shall only be used when approved by DEN Project Manager, two part epoxy, and spacer rings are to be removed to assure the insert is installed properly. The insert used shall be approved, and manufactured for the intent of base can repairs.
In new pavement, all conduits, ducts banks, counterpoise, base cans, etc. shall be installed prior to the placement of the final lift of pavement.

If a light can is installed incorrectly or the duct / conduit is plugged / broken or the concrete joints are installed incorrectly or the light base can is sawed by the concrete saw, the concrete or asphalt pavement around the light base can and the light shall be removed and replaced at the Contractor’s expense. When in concrete, the full panel shall be removed. No partial panel removals will be accepted.

Manufacturer approved means as accepted by the Project Manager shall be used to seal between sections of base cans, spacer rings, and adapter rings. Manufacturer approved means for lubrication fixture flange ring or o-ring shall be used.

All new fixtures shall be provided with properly sized FAA approved transformers.

Each time a fixture is removed, the Contractor shall clean the top of the flange of all sediment preferably with the use of a vacuum. Apply silicone grease to the top of the flange or the O-ring. Provide a new O-ring for existing fixture flanges where new fixtures are being installed. All bolts shall be torqued to manufacturer recommendations.

125-3.2 MAINTENANCE OF EXISTING AIRPORT LIGHTING SYSTEMS DURING CONSTRUCTION. Protect existing airport lighting systems from damage caused during project construction. Any portion of the existing airport lighting systems damaged or disconnected during installation of the new systems, or other construction activities shall be repaired and reconnected. Each circuit must be fully functional prior to dusk each day or during adverse weather conditions, to the satisfaction of the DEN Project Manager. This work shall be at no additional cost to the Owner. All lighting systems serving active taxiways or runways shall be completely operational to the satisfaction of the DEN Project Manager. Any closure to taxiways or runways shall be approved by the Airport.

Dewatering necessary to construct L-125 Items and related erosion and turbidity control in accordance with Federal, State and local requirement is incidental to its respective pay item as part of L-125. The cost of all excavation regardless of type of material encountered shall be included in the unit price bid for the L-125 Item.

125-3.3 INSTALLATION OF BASE CAN IN TURF. Depth of the hole shall be sufficient for the base can as well as any material to be placed below for drainage. Fasten a cover to the can, which shall include gasket at final installation. Base cans shall be surveyed to proper elevation, location and set level. P-610 anchor shall be placed around the base can with a minimum of 6” anchor on all sides of the base can. ID markers shall be incidental to base can installation. Dispose of any unused material as direct by the DEN Project Manager.

The can hub shall be fitted with grommet fittings as shown on the Drawings. Unused openings shall be securely sealed by an approved manufactured means.

For paved areas, base installation shall be as shown on the Drawings. Before paving may proceed, the Contractor shall demonstrate to the DEN Project Manager that the base cans are
at the correct elevation, azimuth and rotation and that the proper clearance exists between the base can the paving train.

In Asphalt paved areas two piece L-867 base cans shall have the bottom section surveyed and conduit installed prior to asphalt pavement, to assure the base can installation is at the correct azimuth and elevation.

125-3.4 SEMI-FLUSH FIXTURE INSTALLATION. Semi-flush lights shall be assembled in accordance with manufacturer’s instructions. The transformer secondary leads shall be connected to the lamp leads by means of a disconnecting plug and receptacle.

Install the fixtures in accordance with the general requirements and details shown on the Drawings. The fixture base and leveling jig shall not be removed until the concrete has sufficiently set.

Proper base can installation is critical to the elevation and alignment of in-pavement lights.

After installation of the light fixture, the azimuth of the light beam shall not vary more than plus or minus ½-degree from the required orientation.

125-3.5 TESTING. Fully test the installation under the observation of the DEN Project Manager by continuous operation for a period of not less than four (4) hours as a completed unit, prior to acceptance by the DEN Project Manager.

Up to two (2) walk-throughs may be initiated by the DEN Project Manager during which the airfield lighting units will be required to be in operation. Additional walk-throughs may be necessary depending upon the number of discrepancies found on the previous walk-throughs.

The Contractor is responsible for lamp replacements and necessary maintenance of airfield items during the testing, construction and walk-through periods.

Test cabling per specification L-108.

The Contractor shall perform the necessary inspection and tests for some items concurrently with the installation because of subsequent inaccessibility of some components. The DEN Project Manager shall be notified by the Contractor forty-eight (48) hours in advance of any testing.

Prior to beginning work, provide written certification that existing light fixtures in area of work are operational.

METHOD OF MEASUREMENT

125-4.1 Refer to Appendix A for Method of Measurement

BASIS OF PAYMENT

125-5.1 Refer to Appendix A for Basis of Payment
MATERIAL REQUIREMENTS

ASTM A615  Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM B8   Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM C827  Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures
ASTM C1107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM D4388 Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tape
SAE AS25050A Colors, Aeronautical Lights and Lighting Equipment, General Requirements for
UL 510    UL Standard for Safety Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape

END OF ITEM L-125
ITEM L-140 FIELD PHOTOMETRIC TESTING

DESCRIPTION

140-1.1 GENERAL. Photometric testing of airfield lighting systems shall be performed by a firm with demonstrated capability for the field measurement of the photometric performance of airfield lighting fixtures. The firm shall have experience in evaluating the test results against FAA standards and manufacturers’ performance criteria. The firm shall demonstrate its capability by having performed similar work successfully at no less than ten (10) international air carrier airports in the past five (5) years. Suggested contacts for this service shall be as follows or approved equal:

   Lean Engineering
   17752 Mitchell N, Suite C
   Irvine, CA 92614
   Phone: (949) 502-8687
   Email: dlean@LeanCorp.com

   Navaid Lighting Associates, Inc.
   141 Autumn Glenn Road
   Saltillo, MS 38866
   Phone: (662) 869-8655
   Fax: (662) 869-0065
   Cell: (662) 322-6418
   Email: david@navaidlighting.com

Photometric testing shall be performed at night between one hour after sunset and one hour before sunrise, with minimum interference to airport operations. Within 24 hours before starting the test, the Contractor shall clean all the light fixtures within the testing schedule to assure that the system is ready for photometric testing. The Contractor shall also verify calibration of constant current regulator output using a true root-mean-squared (RMS) ammeter prior to the testing.

A list of equipment to be used for the photometric testing shall be submitted. In addition, a record of experience on similar projects with references for future contact shall be submitted.

140-1.2 TESTING REQUIREMENTS. The testing shall be performed on all new semi-flush [and elevated runway edge] light fixtures installed as part of this project. [Additional testing of existing semi-flush runway and taxiway lights, and runway edge
lights will be as indicated in the sections under Method of Measurement and Measurement of Payment. No testing is required for elevated taxiway edge lights.

The photometric test equipment shall consist of an array of sensors capable of taking simultaneous light readings as the equipment moves away from a light source. There shall be no loss of accuracy at speeds allowed by the Airport.

The system shall be capable of accurately tracking the position of each sensor relative to the specified main beam area of each fixture type being measured.

The system shall be capable of automatically calculating the average intensity (in candela) in the main beam and 10 percent beam areas to estimate the vertical and horizontal beam alignment (in degrees) by identifying the brightest part of the light beam being measured.

The system shall log the data while testing commences, display the results and identify locations where the minimum average main beam intensities are below the levels listed in FAA AC 150/5345-46 and/or the main beam is mis-aligned either vertically or horizontally.

The system shall log the GPS coordinates for each light fixture while each test is being run.

A print out or electronic copy of the test readings will be made available periodically during the progress of the testing.

The measurements shall be compared to FAA standards as presented in FAA AC 150/5345-46. The calculated averages shall be not less than the minimum average intensities specified in the Advisory Circular in order for the fixture to be considered acceptable. In addition, all readings within the main beam shall be at least fifty percent (50%) of the specified average intensity in order for the fixture to be considered acceptable.

If any of the calculated average readings is below the specified minimum average intensity, or if any individual reading is below fifty percent (50%) of the specified minimum average intensity, additional sets of readings shall be taken as required to identify the problem(s) with the fixture in question.

140-1.3 TEST REPORTS. Initial reports will be submitted periodically during the progress of the work so that corrective measures may be taken as may be required. If the corrective measures are promptly made, the fixtures involved will be reevaluated during the scheduled period of field testing to assure that proper performance has been achieved.

The final test results shall be documented in a Final Report, with six (6) copies submitted to the Airport. The Final Report shall present an evaluation of each fixture tested. For those fixtures that do not meet the performance requirements, the Final Report shall include proposed corrective measures, such as cleaning or replacement of lenses, re-aiming of fixture including resetting of base can, grinding of pavement, repair/replacement of fixture, or any combination of issues. Allowance of the light output to 70% of the minimum average intensity as recommended by AC 150/5340-26, Maintenance of Airport Visual Aid Facilities,
will not be accepted for new fixture installations. [The final test results for existing light fixtures will indicate which fixtures do not meet the performance requirements in addition to the light output level being below 70% of the minimum average intensity listed in AC 150/5345-46.]

The Final Report shall include the following:

a. Performance Bar Chart for each runway or taxiway system, such as Runway 34R centerline or Runway 16L touch down zone. This provides a visual indication of overall performance for the service and identifies the relative position of sub-standard fixtures.

b. Colour Iso-candela diagrams of fixture light output for representative fixtures that have failed due to low light output or mis-alignment.

c. Photometric test data tabulated with the following information:

- Fixture Number
- First and last fixture in a series as shown on the Plans
- Light Direction
- Direction/orientation of light beam
- Max CD
- Maximum candela output in a point along the main beam
- Avg. CD
- Average candela on fixture being tested
- Lens Color
- Color of lens on fixture being tested

d. Max Sensor Reading
- Sensor number (on the sensor bar) that provides the maximum reading.

140-1.4 SPARES. Spare lights provided as part of Item L-125, shall be on-site and available for use by the Contractor prior to the scheduled photometric testing. Any fixtures replaced as part of the photometric testing shall be shipped back to the manufacturer for repair or replacement and delivered back to DEN.

Any of these spares not used for correcting deficiencies shall be delivered to a location on Airport property as directed by the DEN Project Manager.

140-1.5 CORRECTIVE ACTION. The Contractor shall be responsible for correcting any deficient condition identified as a result of the photometric testing. If retesting of corrected conditions can be completed within the originally scheduled field test period, then retesting shall be performed to verify that any deficient condition has been successfully corrected. If retesting is required after the scheduled photometric testing period, additional costs to test corrected fixtures shall be borne by the Contractor.

METHOD OF MEASUREMENT

140-2.1 Runway and taxiway light photometric testing shall be measured as lump sum for all runway and taxiway semi-flush light [and runway edge light] fixtures verified as correct and ready for operation, with documentation submitted to and accepted by the DEN Project Manager.
BASIS OF PAYMENT

140-3.1 Payment will be made at the contract unit price per lump sum for completed and approved testing of new light installations. This price shall be include all labor, equipment, and materials necessary to completely perform all of the work specified, including retesting of the fixtures found to be deficient in the initial testing and corrected by the Contractor. Any photometric retesting shall be paid by the Contractor and is incidental to the installation of the lighting systems.

END OF ITEM L-140